

Becton Dickinson

OPERATOR'S MANUAL

for the



Centrifugal Hematology System

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The QBC System is protected by U.S. Patent Numbers: 4,027,660; 4,082,085; 4,007,396; 4,159,896; 4,156,570; 4,091,659; 4,141,654; 4,137,755; 4,181,609; 4,209,226; 4,259,012; 4,190,328; as well as many foreign patents. Other patents pending.

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Section 1 INTRODUCTION

1.1 INTENDED USE

QBC[®] II Plus (Figure 1.1) is a hematology screening system for obtaining eight quantitative clinical values from a centrifuged tube of blood:

- Hematocrit (HCT)
- Platelet Count (PLT)
- White Blood Cell Count (WBC)
- Granulocyte Count (% and number)
- Lymphocyte-Monocyte Count (% and number) and
- Hemoglobin (HB). ✓



Figure 1.1. QBC II Plus Centrifugal Hematology System.

The platelet and white blood cell counts and those of the granulocyte and lymphocyte/monocyte subpopulations are estimated counts derived from electro-optical measurements of the packed cell volumes in a specially-designed QBC blood tube. Some disease states are characterized by the presence of abnormal white cell types, which may yield normal quantitative relationships of granulocytes to lymphocytes/monocytes. The QBC II Plus system cannot discriminate between normal and abnormal cell types.

1.2 SUMMARY AND EXPLANATION

It has been known for many years that the thin grayish-white buffy coat in the hematocrit tube consists of packed leukocytes and platelets; and that platelets, being less dense, settle in a separate layer above the leukocytes (Figure 1.2).¹ In the 1930's Wintrobe² and Olef³ described methods for estimating elevated white cell and platelet populations based on the milky appearance and thickness of the buffy coat. Quantitative measurements, however, proved difficult because of the very small size and non-homogeneity of the cell layers.

In later studies of cell density gradients, further subdivision or layering was found to occur between two subpopulations of leukocytes (see Figure 1.2) by virtue of their different specific gravities.^{4,5,6} The upper layer was reported to contain predominantly lymphocytes and monocytes; the lower, predominantly the granulocytes, i.e., neutrophils (juvenile, segmented, band), eosinophils, and basophils.

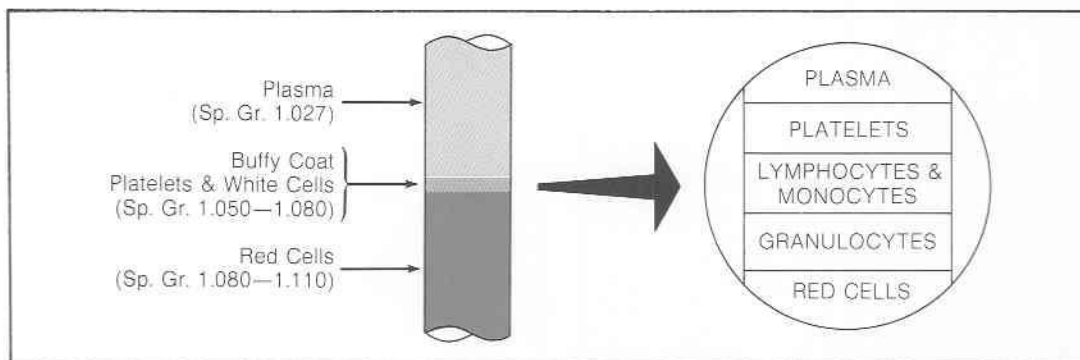


Figure 1.2. Section of Typical Spun Microhematocrit Tube, Showing Relative Densities and Layering of the Formed Elements.

Utilizing mechanical expansion and optical magnification, augmented by supravital cell staining, the QBC method derives a platelet count, white cell count, and counts of the two white-cell subgroups from linear measurements of the packed cell layers in the buffy coat.¹³ As in conventional micro-centrifugation procedures, the hematocrit or PCV is also measured.

Expansion of the buffy layer is achieved by means of a precision-molded cylindrical float, inserted into a precision-bore QBC blood tube before centrifugation. Specific gravity of the float is approximately midway between that of the plasma and red cells, causing part of the float to settle in the buffy coat. Expanded layers of packed white cells and platelets are thereby formed in the annulus between the float and inner wall of the blood tube.

The QBC blood tube is internally coated with the supravital fluorochrome Acridine Orange (AO). Diamidines such as AO have long been employed in cytologic labeling and clinical diagnostics because of their uptake by cellular nucleo-proteins and by glycosamines in the granulocytic series. Under excitation by blue-violet light the cells differentially fluoresce. Histochemical studies of AO-treated blood by Jackson,⁷ for example, confirmed that the granulocytic cells fluoresce orange-yellow; lymphocytes and monocytes, a brilliant green; and platelets, a pale yellow. Erythrocytes, however, are unaffected by AO and exhibit their normal dark red appearance.

The depth that the float sinks in the packed red blood cells when the QBC Tube is centrifuged is a function of red cell density. The lower the red cell density, the more the float will descend into the red cell layer.

Since the primary determinant of red cell density is cellular hemoglobin concentration, the correlation of float depth with hemoglobin concentration is highly significant. This relationship readily allows the hemoglobin concentration to be calculated from measurements of the float depth and the Hematocrit.

The CBC or complete blood count is perhaps the most frequently requested and clinically useful test performed on blood. QBC II Plus provides the physician with CBC-type information within approximately 7 minutes of blood collection. It also enables the physician to quickly identify specimens which have normal or abnormal quantitative relationships of granulocytes to lymphocytes/monocytes and thus to detect specimens which require further investigation and testing.

1.3 PRINCIPLES OF THE PROCEDURE

Two different types of precision bore, 75 mm glass tubes are utilized for QBC tests: one type for venous blood and a different type for capillary blood. The Venous-Blood Tube (Figure 1.3) incorporates a black calibration line and is normally filled by means of the semi-automatic QBC Pipetter supplied with the System. Filled volume is 111.1 μL .

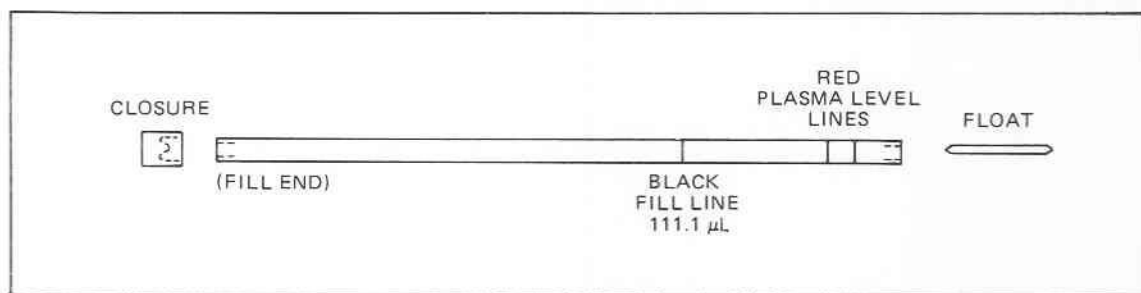


Figure 1.3. QBC Tube for Venous Blood.

To simplify blood collection from a finger puncture, the QBC Capillary-Blood Tube (Figure 1.4) is provided with 55 μL and 65 μL black fill lines. The tube is filled by capillary action to any level between the two lines. As subsequently described, the exact fill volume is measured during the tube reading procedure.

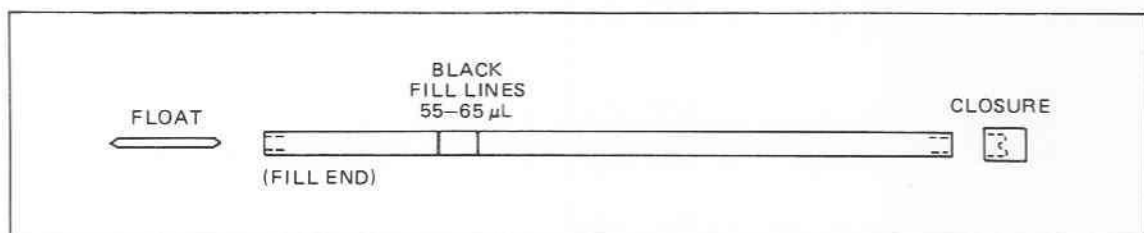


Figure 1.4. QBC Tube for Capillary Blood.

Both types of QBC tubes are internally coated with Acridine Orange and Potassium Oxalate. The former, a supravital fluorochrome, stains the white cells and platelets as previously described. The Potassium Oxalate osmotically removes water from the erythrocytes, causing their density to increase and their volume to shrink. This tends to prevent commingling of certain equal-density erythrocytes and leukocytes at the interfacing boundary between these cell layers.

QBC Capillary-Blood Tubes additionally contain a coating of sodium heparin and di-potassium EDTA to inhibit the clotting of finger-puncture blood.

Each QBC tube is supplied with a plastic closure and float (see Figures 1.3 and 1.4). The float, whose density approximates that of the white cells and platelets, is inserted into the sealed, filled tube immediately prior to high speed centrifugation. Under centrifugal force, the float settles into the buffy coat where it axially expands the formed cell layers by a factor of 10. Part of the float also descends into the red cells (to a variable depth), similarly expanding the upper portion of the packed erythrocyte column and forming a visibly lighter band of red cells surrounding the bottom portion of the float.

Two red plasma-level lines are printed on QBC Venous-Blood Tubes (see Figure 1.3) for checking fill volume in the blood tube prior to testing. Because of the specimen volume displaced by the float, the plasma level must rise between the two red lines after centrifugation. If the plasma is above or below the red lines, the blood tube must be discarded and a new tube prepared.

Layer lengths (packed cell volumes) are measured in the QBC II Plus Reader. A "MODE" button is provided to program the Reader for Venous-Blood Tubes or Capillary-Blood Tubes. By means of an external knob on the side of the Reader, the operator can control the axial position of the tube under a viewing microscope. The tube is "read" by sequentially aligning each interface (starting at the bottom of the red cell column or zero position) with a stationary reticle arrow or cursor within the optical system. The length or thickness of each cell layer is fed into a microcomputer by pressing an "ENTER" button each time an interface is aligned with the cursor. Values for HCT, PLT, WBC, GRANS, and LYMPH/MONO, are displayed on the front panel of the Reader after the last interface has been entered.

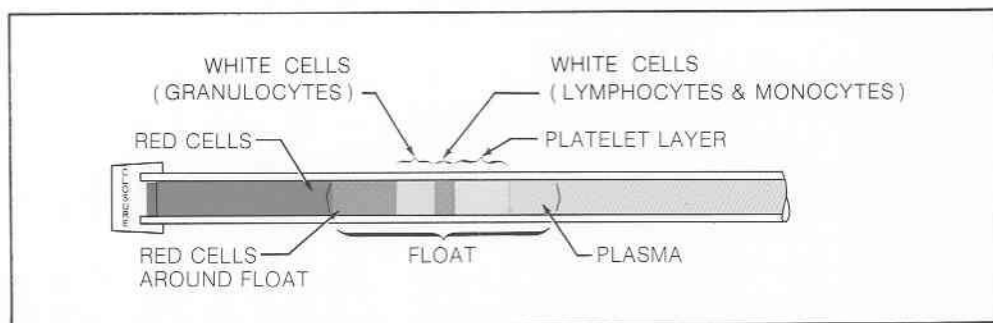


Figure 1.5. Color-Separated Cell Layers in the Spun QBC Blood Tube.

A total of six (6) interfaces in venous-blood tubes and seven (7) interfaces in capillary-blood tubes must be located and entered. In capillary-blood tubes, the length of the plasma column or 7th interface reading is measured in order to determine total fill volume. The latter measurement is utilized by the Reader in computing the capillary-blood hematology parameters.

Hemoglobin concentration is displayed in the "HB(g/dL)" panel readout by pressing the "MODE" button twice while the primary hematology values are on display.

1.4 WARNINGS AND PRECAUTIONS

The QBC II Plus system is intended for In Vitro Diagnostic Use.

Carefully observe all warnings and precautions in this Manual and on labeling accompanying QBC Blood Tubes concerning the safe handling of blood specimens and blood tubes. The use of protective laboratory gloves when handling blood is strongly recommended.

WARNING BLOOD SPECIMENS MAY CONTAIN THE HEPATITIS B VIRUS OR HUMAN IMMUNODEFICIENCY VIRUS (HIV). ALWAYS HANDLE BLOOD SPECIMENS AND BLOOD-DERIVED CONTROLS AS POTENTIAL BIOHAZARDS CAPABLE OF TRANSMITTING INFECTION.
--

Exercise care when using QBC Tubes. Tubes are made of glass and may break.

SECTION 2 INSTALLATION PROCEDURES AND SPECIAL REQUIREMENTS

This Section summarizes instructions for installation, assembly and pre-test preparation of the QBC II Plus System.

NOTE: In the United States, installation of the System will normally be performed by a Becton Dickinson representative. To arrange for installation service or to obtain technical assistance, call the Technical Service Department of Becton Dickinson Primary Care Diagnostics: 1-800-631-8064. Outside the United States, contact your QBC distributor or nearest Becton Dickinson office.

2.1 SYSTEMS AND PACKAGING DETAILS

QBC II Plus Systems are available in 120 volt/60 Hz power ratings as follows:

<u>System No. (for use in)</u>	<u>Reader Model No.</u>	<u>QBC Centrifuge Model No.</u>
4451 (United States)	4452	4207
4450 (International)	4452	4207

The 4451 and 4450 Systems differ only in packaging and minor accessories. The QBC II Plus Reader is equipped with circuitry and a communications port for operation with an Epson printer (see Section 2.2.3).

The following accessories are packaged with the QBC II Plus Reader in addition to this Manual:

- QBC Venous-Blood Pipetter, including spare O-Rings and grease;
- Spare Parts and Accessories Kit containing the following items: Venous and Capillary Calibration Check Tubes; spare lamps, spare fuses; forceps for handling loose floats;
- Countertop Test Guide and Wall Chart; and
- Dust Cover.

A complete re-order list of components, accessories, test disposables and spare parts for the QBC II Plus System is provided in Appendix C of this Manual. For Warranty information, see Appendix D.

2.2 INSTALLATION REQUIREMENTS

2.2.1 Laboratory Environment

Locate the Reader, Centrifuge and test accessories of the QBC II Plus System on a level countertop surface in a clean, dust-free laboratory area. Keep all components of the System out of direct sunlight.

The operating area should be as free as possible from excessive electrical interference from solid state speed-controlled centrifuges, ultrasonic cleaners, diathermy equipment, and data processors, including computers and data terminals.

IMPORTANT: For optimum test results, ambient room temperature must be maintained between 68° and 90°F (20° and 32°C). See Section 7 for instructions on special temperature requirements of QBC hematology tests.

2.2.2 Power Requirements

Plug the power cords of the QBC II Plus Reader and QBC Centrifuge into grounded electrical receptacles rated for the line voltage and frequency specified on their respective data plates.

CAUTION

Connect power cords only to 3-wire grounded receptacles delivering the voltage and frequency specified on the data plate on the back of each instrument. When only a 2-wire receptacle is available, have it replaced with a properly grounded 3-wire receptacle by a qualified serviceman and in accordance with the National Electrical Code. Do not remove the grounding prong from the power cord. If an extension cord is required, use only a 3-wire grounded cord having the proper voltage and current rating.

For proper functioning of the QBC II Plus Reader and QBC Centrifuge, voltage output of the power source must be between 105 and 130 volts. If the line voltage is known to fluctuate outside these limits, notify the Installer. The use of a special voltage regulator may be required.

2.2.3 Printer Utilization

A Becton Dickinson Catalog No. 4482 Printer Package or equivalent components are required for automatic recording of QBC II Plus test results on pressure-sensitive labels. The Printer Package contains an Epson LX-series Printer, Printing Labels, Epson Manual, and a Reader-to-Printer Cable Assembly.

Note: An Epson LX-series Printer can be purchased locally; however, the special Reader-to-Printer Ribbon Cable Assembly (Catalog No. 4407) is required and must be ordered separately from Becton Dickinson via your local distributor.

a. Connecting Reader-to-Printer Cable

To install the special Ribbon Cable Assembly supplied in the Catalog No. 4482 Printer Package (or ordered separately under Catalog No. 4407), refer to Figure 2.1 and perform the following:

- 1) Insert the 25-pin plug of the Ribbon Cable Assembly into the "PRINTER" connector in the back panel of the Reader.
- 2) Secure the plug to the connector by manually tightening the knurled Captive Screws to the Jacksockets of the connector. Note: the Captive Screws are slotted and can be tightened with a screwdriver.
- 3) Connect the unattached connector of the Ribbon Cable to the plug on the Epson Printer as described in Epson's operating manual.

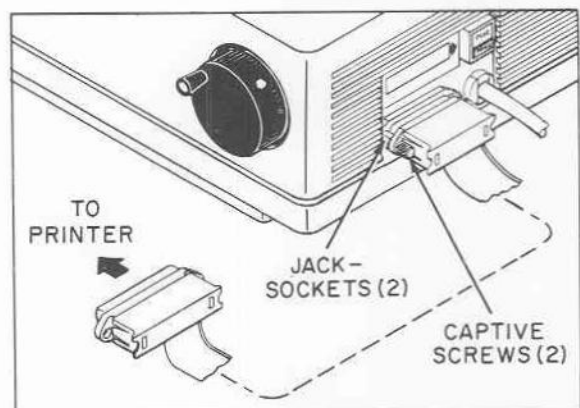


Figure 2.1. Ribbon Cable Connection From Reader to Printer.

b. Printer and Electrical Ratings

Interface circuitry and control codes in the QBC II Plus Reader are compatible only with Epson LX-series Printers. Do NOT attempt to connect any other printer.

If an Epson LX-series Printer is purchased locally, be sure the electrical rating of the Printer is compatible with the electrical rating of the Reader.

c. Operating Instructions

See Appendix B for operating details with a Reader-Printer system. Instructions for operating the Epson printer are provided in the manufacturer's handbook.

2.3 ASSEMBLY OF CENTRIFUGE ROTOR

The rotor of the QBC Centrifuge must be assembled onto the motor shaft of the instrument before use. Complete instructions are contained in the Operator's Manual supplied with the Centrifuge.

2.4 CALIBRATION CHECK TUBES

2.4.1 Description and Use

Two Calibration Check Tubes - one for Venous Mode and one for Capillary Mode - are included in the Spare Parts and Accessories Kit supplied with the QBC II Plus Reader. Each Check Tube consists of a 75 mm glass capillary tube containing alternating black and white segments of plastic in a stable liquid medium. Both ends are internally sealed to prevent fluid leakage; one end is capped with a standard QBC tube closure. When inserted in the Reader the white plastic segments fluoresce a pale green. Note: The Check Tubes are not designed to duplicate the color or appearance of cell layers in blood-filled QBC tubes.

The Check Tubes are provided to verify acceptable performance of the Reader prior to hematology tests of patient samples. Procedures for daily use of the Check Tubes are described in Section 4.6.1.

2.4.2 Determining and Recording Calibration Tolerances

Upon installation of the QBC II Plus Reader, tolerances for each Check Tube must be determined and recorded on the Package Insert within each Check Tube vial. The recorded tolerance values are then used in the daily performance checks of the Reader (see Section 4.6.1).

Detailed procedures for determining calibration tolerance values are described in the Package Insert within the Check Tube vials. The procedures should normally be performed by the primary operator of the Reader after suitable training and under the guidance of the Becton Dickinson Installer. New calibration tolerance values should always be established when there is a change in operators.

IMPORTANT: The Hemoglobin (HB) value obtained from reading the Calibration Check Tubes may flash on and off due to a software program in the Reader, which is designed to detect red-cell abnormalities in whole blood. Flashing HB values, however, should always be used when calculating the mean check values for hemoglobin as described in the direction inserts packaged with the Calibration Check Tubes.

Section 3
PRINCIPLES OF OPERATION AND SPECIFICATIONS

3.1 SYSTEM COMPONENTS

As previously described, the QBC II Plus System consists of an electro-optical Reader and a high speed QBC Centrifuge for producing packed, differentiated cell layers. Standard accessories include a Work Station and Venous-Blood Pipetter. Each of the above components is described in subsequent paragraphs of this Section.

3.2 QBC II PLUS READER

The QBC II Plus Reader (Figure 3.1) is a microprocessor-controlled electro-optical instrument for measuring packed cell volumes and converting these measurements into the hematocrit, blood cell counts, and hemoglobin.

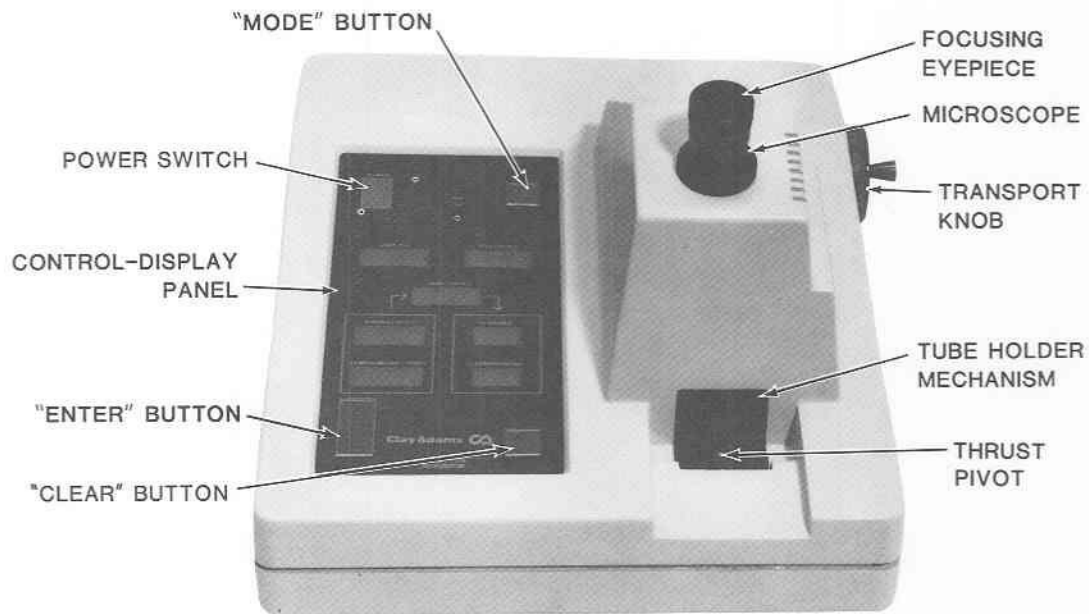


Figure 3.1. External Features of QBC II Plus Reader.

Major functional sections of the Reader are the mechanical-optical system and interconnecting microprocessor electronics system for mode selection, data input, information processing, and readout display.

3.2.1 Mechanical-Optical System

Mechanical and optical components of the QBC II Plus Reader are shown in Figures 3.2 and 3.3.

A centrifuged QBC blood tube is inserted into the Tube Carriage Mechanism and viewed through the Microscope as the tube is rotated about its longitudinal axis at approximately 1400 rpm. Rotational movement is imparted to the tube by a motor-driven roller within the Carriage Assembly. The Carriage Assembly can be moved axially, in and out, along a threaded shaft (lead screw) and guide rod. By means of miter gears linked to the external Transport Knob, the threaded shaft can be turned to move the complete Carriage Assembly and rotating blood tube under the Microscope lens. As the blood tube is moved, a position transducer (optical encoder) transmits electrical pulses proportional to the axial distance that the blood tube is moved.

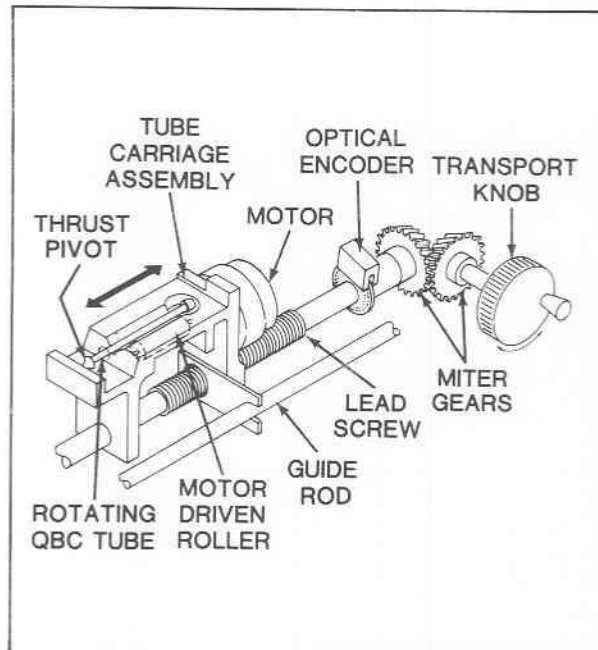


Figure 3.2.
Tube Reader Mechanical System

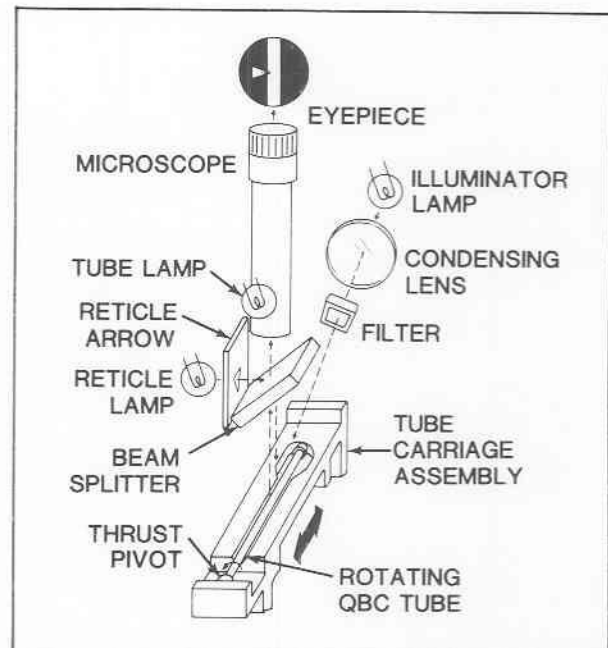


Figure 3.3.
Tube Reader Optical System.

An illuminator lamp, through a lens and filter system, continuously radiates blue-violet light at an excitation wavelength sufficient to cause the stained white cells and platelets to fluoresce. A barrier filter within the microscope effectively blocks the transmission of blue-violet from the viewer's eye. Momentary white light from a Tube Lamp illuminates the interface between the dark and light layers of red cells (2nd interface).

By causing the blood tube to rotate around its longitudinal centerline, cell layer boundaries are viewed around their entire perimeters, thereby optically averaging irregularities at their interfaces.

A stationary, back-lighted reticle arrow or cursor (see Figures 3.3 and 3.4) is provided in the optics for aligning and "reading" interfaces in the rotating blood tube. Starting at the first or I_1 interface (at the closure-to-bottom of the dark red cell layer), lengths of the five packed cell columns (and plasma column in Capillary Tubes) are measured. See Figures 3.5 and 3.6.

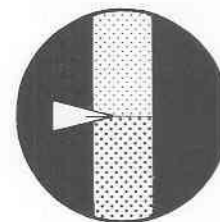


Figure 3.4. Reticle Arrow and QBC Tube Viewed Through Microscope of Reader.

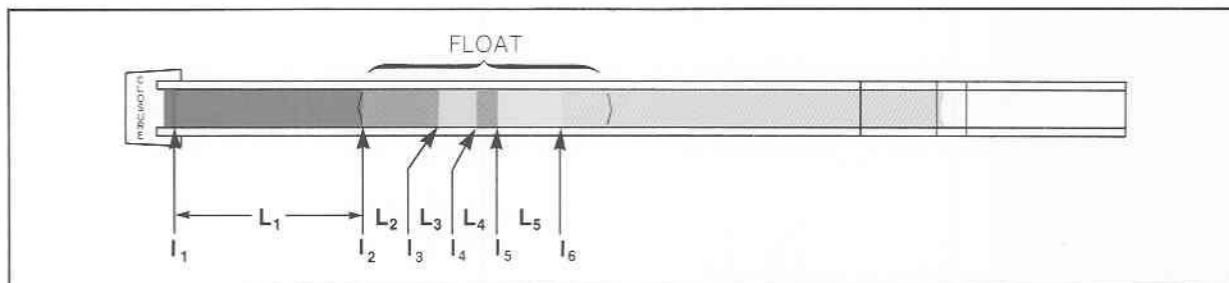


Figure 3.5. Layer Lengths Measured in QBC Venous-Blood Tube.

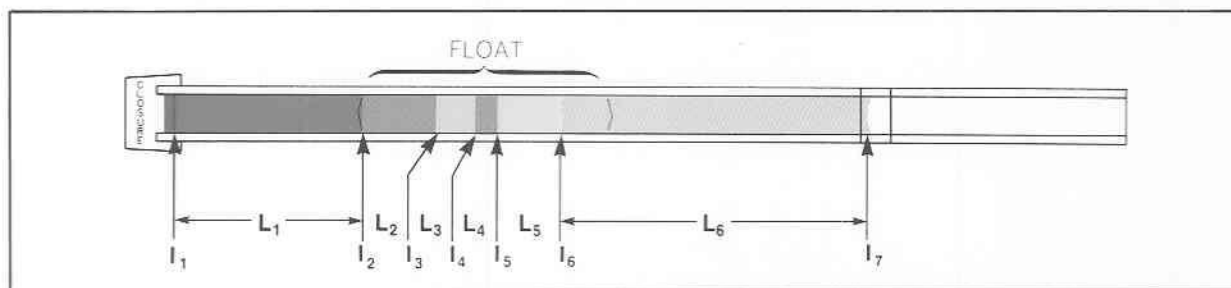


Figure 3.6. Layer Lengths Measured in QBC Capillary-Blood Tube.

As each interface is aligned with the reticle arrow, an "ENTER" button (see Figure 3.1) on the Control Panel is pressed. Electrical pulses generated by rotational movement of the optical encoder are fed to a pulse counter and processed by the microcomputer, which computes values for the hematology parameters from lengths of the measured cell layers (and plasma column in QBC Capillary-Blood Tubes). The lengths are also used to compute hemoglobin concentration based on a computer-stored algorithm.

3.2.2 Microprocessor-Electronics System

The microprocessor-electronics system includes the incremental position encoder, mounted on the threaded shaft or lead screw (see Figure 3.2). The encoder produces 2-phase electrical pulses proportional to the axial distance the blood tube is moved. An up/down counter converts the output pulses to a count proportional to the length of the cell layer being measured. Fixed and programmable constants are utilized by the computer in calculating the cell counts. The "ENTER" button controls operation of the counter and computer. Except for the first interface, each time "ENTER" is pressed, it signals the end of one layer measurement and the beginning of the next. After the final interface is read, the computer displays the test results. Hemoglobin is then displayed by pressing the MODE button twice within 2 seconds. Pressing "ENTER", at the 1st interface of the next blood tube, automatically clears the display and resets the Reader.

The microprocessor monitors the position ("VEN" or "CAP") of the MODE button and selects the correct program for computing test values from measurements of venous-blood or capillary-blood tube. QBC hematology parameters are functions of the following linear measurements (see Figure 3.5):

- | | | | |
|---------------|-----------------|-------------------|--|
| • Hematocrit: | L_1 and L_2 | • Platelet Count: | L_5 |
| • WBC: | L_3 and L_4 | • Hemoglobin: | Derived from L_1 , L_2 , L_3 , L_4 and L_5 |
| • GRANS: | L_3 | | |
| • LYMPH/MONO: | L_4 | | |

Stored constants utilized in the computation of hematocrit correct for: shrinkage of the red cells due to potassium oxalate; volumetric expansion of the packed cells by the float, and float and closure geometry. Mean cell volumes and float expansion factors are applied in the WBC and Platelet Count computations. Hemoglobin is derived from an algorithm based on the hematocrit (L_1 and L_2) and the lengths of the packed white-cell and platelet layers (L_3 , L_4 and L_5).

The derivation of test values from QBC Capillary-Blood Tubes utilizes the same length measurements described above but different calculation functions based on length of the plasma column L_6 (see Figure 3.6).

The microprocessor also controls the readout displays, internal auxiliary light, and error detection systems. The latter systems actuate service and procedure alert "flags", which are displayed when an irregular condition is detected in the computer memory or in the tube-reading procedure. For a discussion of service and alert flags, see Sections 4.1 and 4.3.3.

3.2.3 Control-Display Panel

The control-display panel of the Reader (Figure 3.7) incorporates the following switch buttons:

- **POWER:** Energizes the Reader and initiates an automatic self-test sequence of lamps and microprocessor (see Section 4.1). Illuminated green when ON.
- **MODE:** IN position - activates the "VEN" mode indicator light and programs the Reader for venous blood tests. OUT position - activates the "CAP" mode indicator light and programs the Reader for capillary blood tests. Also activates a display of the Hemoglobin value.
- **ENTER:** Supplies data to the computer, locating the beginning and end of each packed cell layer.
- **CLEAR:** Erases test values from the displays, initiates a self-test sequence, and resets the Reader for a new test.

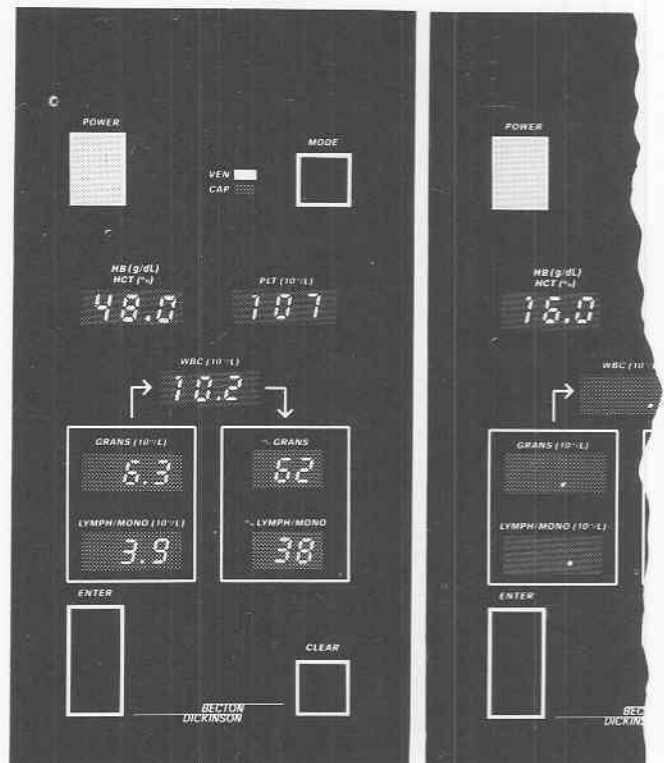


Figure 3.7. Control-Display Panel of QBC II Plus Reader.

The seven panel readouts will display test values momentarily after pressing "ENTER" at the final interface; the hemoglobin result is displayed by pressing the "MODE" button twice. Units and digit-decimal format of QBC II Plus test parameters are as follows:

• HCT (%)	XX.X	• GRANS ($10^9/L$)	XX.X
• HB (g/dL)	XX.X	• LYMPH/MONO ($10^9/L$)	XX.X
• PLT ($10^9/L$)	XXX	• GRANS (%)	XX
• WBC ($10^9/L$)	XX.X	• LYMPH/MONO (%)	XX

Upon detection by the microprocessor of an irregularity in the tube reading procedure, an alpha-numeric message will flash in the appropriate readout to alert the operator of an error condition. (See discussion in Section 4.3.3.)

3.3 QBC CENTRIFUGE

The QBC Centrifuge (Figure 3.8) is a high-speed instrument, specifically designed to meet the cell packing requirements of the QBC test methodology. Up to 12 blood tubes can be spun simultaneously at a nominal speed of 12,000 RPM and relative centrifugal force of approximately $14,387 \times g$. Spin time is fixed at 5 minutes.

A detailed description of the QBC Centrifuge, including set-up and operating instructions, is contained in the separate Operator's Manual shipped with the Centrifuge.



Figure 3.8. QBC Centrifuge.

3.4 WORK STATION

The QBC Work Station (Figure 3.9) is a convenient test accessory to facilitate the preparation and storage of QBC blood tubes.

The Work Station incorporates a platform to hold a 10-test tray of QBC blood tubes; a slotted receptacle for storage of the QBC Venous-Blood Pipetter (see below); various sized blood tube wells; and a notched front rack for storage of centrifuged QBC Blood Tubes.

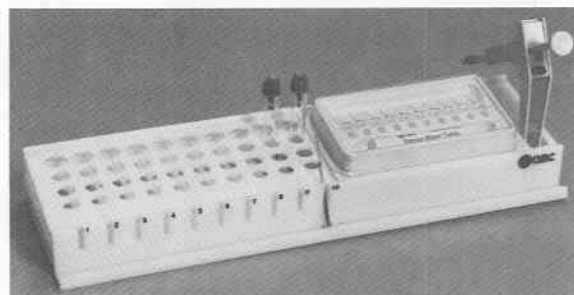


Figure 3.9. QBC Work Station and Venous-Blood Pipetter.

3.5 VENOUS BLOOD PIPETTER

The semi-automatic Pipetter shown in the Work Station in Figure 3.9 is a dedicated device, designed exclusively for filling QBC Venous-Blood Tubes. The plunger of the Pipetter has two positions: fully retracted and fully depressed. In the depressed position and with a QBC Venous-Blood Tube inserted into the metal coupling of the Pipetter, the plunger is gradually released to aspirate blood into the tube. Fill volume is fixed at 111.1 μL and is non-adjustable.

3.6 SYSTEM SPECIFICATIONS

3.6.1 QBC II Plus Reader

- Tube-Viewing Microscope:
Magnification: 7.5x
Adjustable Eyepiece with Blocking Filter
- Test Environmental Requirements:
Temperature: 68° to 90°F (20° to 32°C)
Relative Humidity: 10% to 95% (non-condensing)
- Electrical

<u>Reader Model No.</u>	<u>Volt.</u>	<u>Freq.</u>	<u>Watts</u>	<u>Main Power Fuse</u>
4452	120	60Hz	80	3AG 1-1/2 Amp Slo-Blo

Three-wire grounded cord and plug.

- Weights and Dimensions:
Reader Weight: 4.3 kg (9.5 lb)
Reader Dimensions: 36.2 cm deep x 34.3 cm wide x 25.4 cm high (14.25" x 13.5" x 10")
Shipping Weight (including accessories): 6.8 kg (15 lb)
Shipping Container Dimensions: 49.5 cm x 54.6 cm x 44.5 cm (19.5" x 21.5" x 17.5")

3.6.2 QBC Centrifuge*

- Speed: Nominal at Rated Voltage: 12,000 RPM
- Relative Centrifugal Force (RCF) at Nominal Speed: 14,387 x g
- Rotor Capacity: 12 QBC Blood Tubes
- Timer: Internal Electronic - 5 minutes (fixed)
- Electrical

<u>Model No.</u>	<u>Volt.</u>	<u>Freq.</u>	<u>Amp.</u>
4207	120	60Hz	4

*See QBC Centrifuge Operator's Manual for Complete Specifications.

Section 4 OPERATING INSTRUCTIONS

This Section contains general instructions for operating the various components and accessories of the QBC II Plus System. Maintenance and Service procedures are contained in Section 5.

Note: For detailed directions on blood collection, specimen preparation, and test procedures, consult Sections 6 and 7.

4.1 SELF-TEST SEQUENCE

Each time the "POWER" button of the Reader is activated a brief self-test sequence is initiated to check the operation of all lamps and to verify certain computer functions. The self-test sequence also occurs whenever the "CLEAR" button is pressed.

In the lamps check phase of self-test, numeral "8"s should appear in all digit positions of the readouts, and all panel indicator and internal lamps should momentarily light. Note: If a lamp segment in any readout digit is missing or an internal lamp fails to light, see Sections 5.3.3 and 5.3.4 for replacement procedures.

The computer check phase of self-test is satisfactory, provided a flashing service flag "P1" or "P2" does not appear in the PLT (Platelet) display. If a "P1" or "P2" flag appears, the Reader will not function until the problem is corrected. When either flag appears, the operator should check for a transient condition by pressing the "CLEAR" button several times. If the service flag persists, REQUEST TECHNICAL ASSISTANCE.

4.2 DAILY START-UP ROUTINE

Before daily testing of patient specimens, perform the following procedures in the order listed:

- 1) Press the POWER switch ON and monitor the Self-Test Sequence for satisfactory operation of all lamps and readout displays.
- 2) Run performance checks of the Reader in each mode ("VEN" and "CAP") according to 4.6 of this Section. The checks include mandatory testing of Calibration Tubes and optional testing of QBC Controls.

When satisfactory performance checks are completed, the Reader is ready for blood tube measurements.

4.3 OPERATING THE READER

4.3.1 Inserting and Removing Blood Tubes

Before inserting or removing a blood tube, always turn the Transport knob counterclockwise until it stops and the tube holder mechanism is in the fully down position as shown in Figure 4.1.

To insert a blood tube: hold the tube near the open end and insert the closure end upward into the Reader (Figure 4.2); then gently lower and release the tube so that the open end of the tube rests in the center of the thrust pivot.

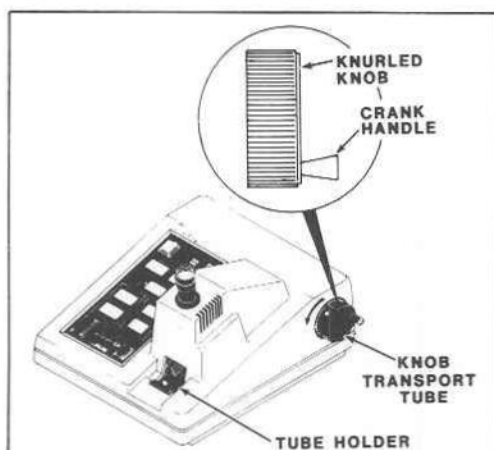


Figure 4.1.

Tube Holder Shown in Down Position.

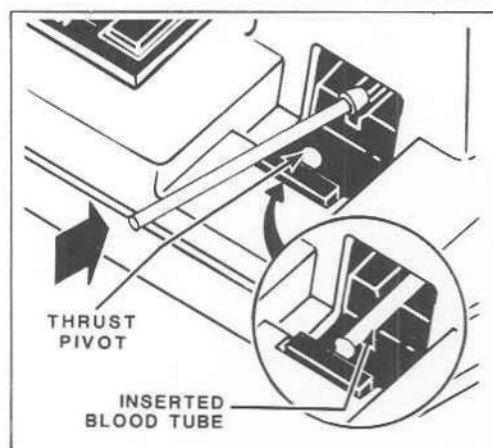


Figure 4.2.

Inserting Blood Tube into Reader.

Referring to the inset in Figure 4.1, the Tube Transport Knob consists of a small crank handle on a larger knurled knob. Use the crank handle for fast movement of the tube holder, e.g., when lowering the holder to remove a blood tube or when moving a tube inward to start a reading. For fine adjustment, use the knurled knob to align a cell interface with the reticle arrow.

4.3.2 Blood-Tube Reading Procedures

To read a blood tube, select the desired mode (VEN or CAP), insert the tube and perform the Reading Sequence described in Figure 4.3.

IMPORTANT: When reading QBC blood tubes, the two layers of Red Cells must always be followed by an ORANGE-YELLOW layer of granulocyte cells as shown in Figure 4.3. If a GREEN layer instead of an Orange-Yellow layer appears directly above the Red Cells, **DISCONTINUE THE READING PROCEDURE AND DISCARD THE TUBE**. If a freshly prepared QBC tube of the same patient specimen continues to exhibit a GREEN layer directly above the Red Cells, test the specimen by another method.

CAUTION
TEST VALUES OBTAINED BY AN INCORRECT READING PROCEDURE
ARE INVALID AND MUST NOT BE USED FOR DIAGNOSTIC PURPOSES.

Test values for seven QBC parameters, except Hemoglobin, will automatically appear in the readouts momentarily after pressing "ENTER" at the 6th interface in Venous-Blood Tubes and 7th interface in Capillary-Blood Tubes. Refer to 4.3.3 to obtain a display of Hemoglobin results. Test values from the completed reading will remain displayed until "ENTER" is pressed again (i.e., 1st reading of next tube) or the "CLEAR" button is pressed.

4.3.3 Obtaining Hemoglobin Value

a. Normal Reader Operation

Hemoglobin concentration is displayed using the MODE button. Before activating a hemoglobin display, test values for the 'primary' hematology parameters

"CAP" Mode Only

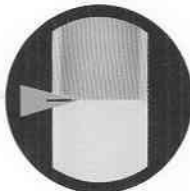
Move tube inward until cursor is at meniscus of TRANSLUCENT GREEN plasma column (7th Reading).

7th (Final) Reading



Press ENTER. Record the seven hematology values; then press the MODE button twice to obtain HB.

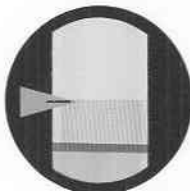
6th Reading



Press ENTER. In VENOUS mode: Record the seven hematology values; then press the MODE button twice to obtain HB.

Move tube inward until cursor tip is at interface between PALE YELLOW layer and TRANSLUCENT GREEN plasma (6th Reading).

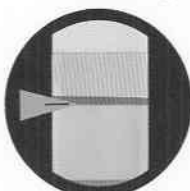
5th Reading



Press Enter.

Move tube inward until cursor tip is at interface between BRIGHT GREEN and PALE YELLOW layers (5th Reading).

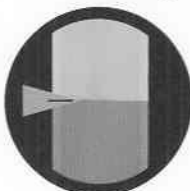
4th Reading



Press Enter.

Move tube inward until cursor tip is at interface between top of ORANGE-YELLOW layer and bottom of DARK BAND (4th Reading).

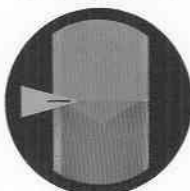
3rd Reading



Press Enter.

Move tube inward until cursor tip is at interface between LIGHT RED and ORANGE-YELLOW layers (3rd Reading).

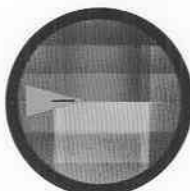
2nd Reading



Press ENTER. The white tube lamp will turn off.

Move tube inward until cursor tip is at bright edge of float between DARK RED and LIGHT RED layers (2nd Reading).

1st Reading



Press ENTER. The white tube lamp will light.

Move tube inward until cursor tip is at interface between GREEN closure and bottom of RED cells (1st Reading).

Figure 4.3. Tube Reading Sequence, QBC Venous and Capillary Blood Tubes.

must be on display in the seven readouts. To obtain Hemoglobin:

- Press and release the MODE button TWO TIMES within 2 SECONDS.
- The Hemoglobin concentration [in grams per deciliter (g/dL)] will appear in the Hematocrit display, and the remaining readouts will be blank.

To re-display the HCT, WBC, PLT, GRAN and LYMPH/MONO results from the same QBC tube, press and release the MODE button 2 TIMES within 2 SECONDS.

Note: If the MODE button is pressed twice, but the time delay between the first and second presses exceeds 2 seconds, the test results appearing in the readouts (7 parameters or HB only) will not change.

b. Causes for No HB or Flashing HB Values

Flashing dashes ("---") with no test value will appear in the HB display whenever an alert flag is present for any other test parameter (see 4.3.5 below). Additionally, no HB value will appear when the following occur:

- HCT is below 15 % or above 65 %; or
- The computed HB is below 5 g/dL or above 20 g/dL.

The HB test value will flash on and off when the red cell density factor, which is used in deriving hemoglobin, is above or below programmed limits. Whenever the HB test value flashes, the sample should be examined more closely (i.e., by a peripheral blood smear) to determine the nature of the abnormality.

4.3.4 Reader Operation with Optional Printer

When the QBC Plus II installation includes an Epson Printer and the Reader/Printer is operational, data transmission of test results - including Hemoglobin - is initiated within microseconds after pressing "ENTER" at the last (6th or 7th) interface of the QBC Tube. See Appendix B for additional information.

With an Epson LX-series printer, test results will appear on the panel while ticket printing is in progress. Hemoglobin concentration can be displayed without affecting the printing operation.

4.3.5 Procedure Alert Flags

When the Reader detects an out-of-range or irregular condition during tube reading, an alert flag, consisting of a flashing letter, number, or combination of both, will appear in a panel readout. The specific readout in which a flag appears, and whether or not the flag is accompanied by valid test values in other readouts, is determined by the nature of the flagged condition. Table IV-1 lists the alert flag program, the probable cause of each flag, and recommended corrective action.

The "Probable Causes" listed in Table IV-1 opposite the H1, H2, L2, A8 and 999 flags assume that the operator has read every interface in its correct sequence and that none was inadvertently skipped. For a more detailed discussion on the causes of each flag, consult Appendix A.

TABLE IV-1. QBC II Plus Alert Flags

FLASHING ERROR FLAG (TEST MODE)	PROBABLE CAUSE(S) OF ERROR FLAG	CORRECTIVE OPERATOR ACTION
-L (VEN or CAP)	1. Tube was inadvertently moved in wrong direction from last interface reading. 2. "ENTER" was inadvertently pressed twice while blood tube was at the same interface, resulting in a layer measurement of zero. 3. "ENTER" was pressed twice at the same interface to record the length of a <i>missing</i> white cell layer or the platelet layer.	1. Press "RESET" and repeat test from beginning. Follow proper tube-reading sequence. 2. Press "RESET" and repeat correct tube reading sequence. 3. DISCARD TUBE. Test the specimen by other methods.
H2 (VEN or CAP) AFTER ENTERING 2nd INTERFACE	1. Venous blood tube is plasma-rich because specimen was not mixed before filling the tube. 2. Float is defective. 3. Blood tube contains insufficient specimen due to filling error or blood loss.	1. DISCARD TUBE. Prepare new tube using <i>well-mixed</i> specimen and repeat test. 2. DISCARD TUBE. Prepare new tube and repeat test. 3. DISCARD TUBE. Prepare new tube and repeat test.
H1 (VEN or CAP) AFTER ENTERING 3rd INTERFACE	1. Float is defective, causing top of light red cell layer (L₂) to extend beyond top of float, preventing an accurate HCT, WBC, PLT and HB. 2. High HCT or blood abnormality.	1. DISCARD TUBE. Prepare new tube and repeat test. 2. DISCARD TUBE. Test specimen by other methods.
L2 (VEN Only) AFTER ENTERING 4th INTERFACE	1. High count or blood abnormality, causing top of orange-yellow GRAN layer (L₃) to extend beyond top of float, preventing an accurate WBC, PLT and HB. NOTE: Valid HCT value will be displayed.	1. Test the blood specimen by other methods for WBC, PLT and HB.
L2 (VEN Only) AFTER ENTERING 5th INTERFACE	1. High count or blood abnormality, causing top of green LYMPH/MONO layer (L₄) to extend beyond top of float, preventing an accurate WBC, PLT and HB. NOTE: Valid HCT will be displayed.	1. Test the blood specimen by other methods for WBC, PLT and HB.
L2 (VEN Only) AFTER ENTERING 6th INTERFACE	1. High count or blood abnormality causing top of orange-yellow layer (L₅) of platelets to extend beyond top of float, preventing an accurate PLT and HB. NOTE: Valid HCT, WBC, GRAN and LYMPH/MONO will be displayed.	1. Test the blood specimen by other methods for PLT and HB.
AB (CAP Only)	1. Capillary Blood Tube contains too much specimen or insufficient specimen. 2. High count or blood abnormality, causing white cell or platelet layer to extend beyond top of float.	1. DISCARD TUBE. Prepare new tube, filled to required level. 2. DISCARD TUBE. Test the blood specimen by other methods.
--- (VEN or CAP)	• In HCT: High computed value exceeds dynamic capabilities of instrument, preventing display of HCT. • In HB: No value due to other error flag or out-of-limit HCT or HB (see 4.3.3b).	• In HCT: DISCARD TUBE. Test the blood specimen by other methods. • In HB: Test for HB by other methods.
99.9 (VEN or CAP)	In WBC: Computed WBC exceeds three digit limitation of Reader display.	In WBC: Test specimen for WBC by other methods.
999 (VEN or CAP)	Computed PLT exceeds three digit limitation of Reader display.	Test specimen for PLT by other methods.

OVER RANGE OR
NO TEST VALUE FLAGS

To clear an alert flag and re-set the microprocessor, press the "CLEAR" button. Repeat the reading sequence, depending on the nature of the flagged condition.

4.4 QBC CENTRIFUGE OPERATION

Place blood tubes on the rotor of the QBC Centrifuge by inserting the open end of the tube under the flange of the rotor nut and lowering the tube into the tube slots. Position the closure snugly against the outer rim of the rotor.

Always place blood tubes on the centrifuge rotor in a balanced array. When spinning an odd number of tubes, balance the rotor with an empty QBC blood tube, fitted with a Closure and Float, in the rotor position opposite the odd tube.

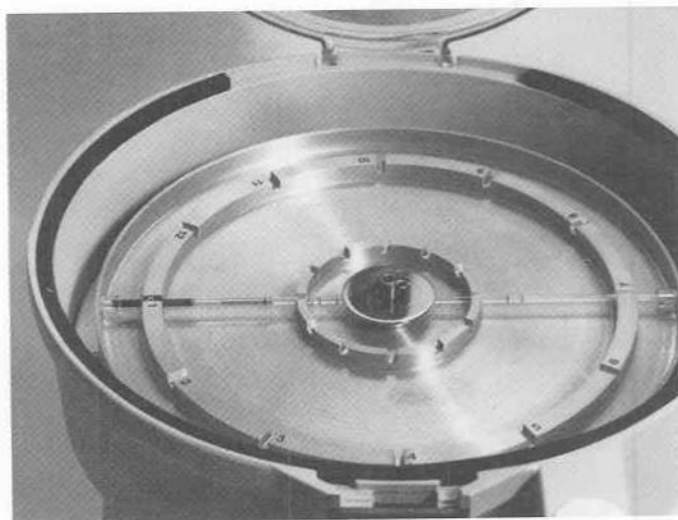


Figure 4.4. Single QBC Tube On Centrifuge Rotor, Showing Balance Tube in Opposite Position.

To install the rotor cover, place the cover onto the threads of the motor shaft and turn the knurled cover nut clockwise. Hold the cover with one hand and continue turning the nut clockwise until tight.

CAUTION
TO PREVENT TUBE BREAKAGE AND LOSS OF
SAMPLES, NEVER CENTRIFUGE BLOOD TUBES
UNLESS THE ROTOR COVER IS INSTALLED.

Close the lid by pressing firmly down until the lid latch engages the latch block. The Centrifuge will not operate unless the lid is securely latched.

Note: The timing cycle of the QBC Centrifuge is fixed at 5 minutes. The Centrifuge incorporates no timer selector or timing adjustment.

To start the Centrifuge, lightly press the PUSH-TO-START/PUSH-TO-STOP button. The button will light and remain on until the 5-minute spin cycle is completed and power to the motor is cut off. **DO NOT OPEN THE CENTRIFUGE UNTIL THE ROTOR HAS STOPPED.**

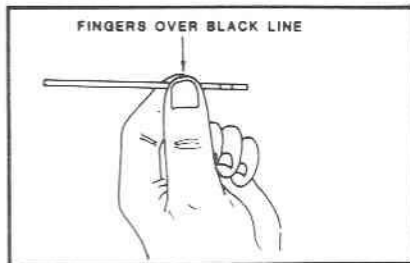
Note: Detailed operating instructions for the QBC Centrifuge are contained in the Manual supplied with the Instrument.

4.5 USING THE PIPETTER

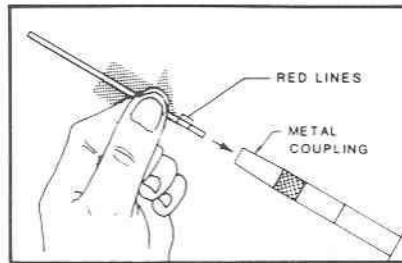
The QBC Pipetter is a fixed-volume device designed exclusively for aspirating blood into QBC Venous-Blood Tubes. **DO NOT USE THE PIPETTER WITH QBC CAPILLARY-BLOOD TUBES, WITH OTHER FLUIDS, OR FOR ANY OTHER PIPETTING PROCEDURES.**

CAUTION
EXERCISE CARE WHEN INSERTING QBC TUBES INTO THE PIPETTER. THE TUBES ARE MADE OF GLASS AND MAY BREAK.

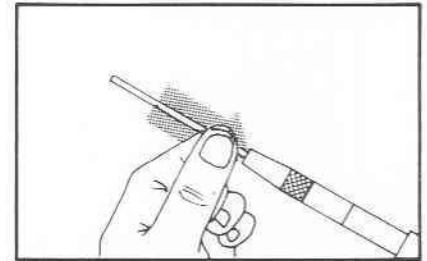
In order to prevent breakage and to assure complete seating of QBC Venous-Blood Tubes in the Pipetter, carefully observe the illustrated procedures in Figure 4.5 when inserting a tube.



STEP 1 — Hold the QBC tube between the thumb and forefinger directly over the black fill line. Maintain the same tube-holding position in Steps 2 and 3.



STEP 2 — Carefully insert the tube (end nearest the red lines) into the metal coupling of the pipetter until the tube appears to stop.



STEP 3 — Finally, press the tube firmly inward until it is fully seated and captured by the O-ring inside the coupling. Extra pressure is sometimes required to overcome a tight O-ring seal. **IMPORTANT: DO NOT ATTEMPT TO INSERT THE TUBE BY HOLDING AND PRESSING THE DISTAL END.**

Figure 4.5. Technique for Inserting QBC Venous-Blood Tube into Pipetter.

To fill a Venous tube, depress the plunger of the pipetter fully in until it stops (fill position); then insert the distal end of the tube into a well-mixed anticoagulated blood specimen. Release finger pressure slowly and smoothly until the plunger returns to its fully retracted position. Wipe excess blood from the outside surface of the tube with a lint-free tissue. Be careful not to touch the distal opening, which can result in the loss of specimen.

After each filling procedure, hold the Pipetter so that the tube is horizontal and check that the blood level is within ± 1 millimeter of the black line.

The QBC Pipetter is a precision device that has been factory-calibrated to aspirate 111.1 microliters of blood with an accuracy of $\pm 2\%$, equivalent to approximately ± 1 millimeter above or below the black fill line. After extended use, O-ring seals in the Pipetter may become worn and require replacement. Replacement is indicated by failure of the Pipetter to aspirate blood to within the ± 1 mm fill tolerance, or by leakage of blood from the distal end of the tube. A leakage check can be made by observing the blood level while holding the Pipetter so that the blood tube is vertical. If the blood level drops 1 mm within about 30 seconds, the O-rings should be replaced. Spare O-rings are supplied with the Pipetter. See Section 5.3.10 for O-ring replacement instructions.

Note: If the Pipetter malfunctions, tubes can be filled by capillary action.

4.6 CALIBRATION AND QUALITY CONTROL

As previously described, two Calibration Check Tubes are supplied with the QBC II Plus System to monitor acceptable performance of the Reader in the venous mode and capillary mode. (Use of the Check Tubes is specified as part of the Daily Start-up Procedures in Section 4.2.)

The Check Tubes serve to verify the ability of the Reader to measure band lengths and to derive values within factory-set tolerances. Acceptable performance of the following primary electro-optical and computer components is thereby confirmed: tube position encoder; encoder-to-microprocessor data link; write-in/readout functions of the Random Access Memory (RAM); readout function of the Read Only Memory (ROM); software computation module; and the algorithms (venous and capillary) for computing HCT, WBC, GRANS, LYMPH/MONO, Platelet and HB parameters at the specific assay levels (length measurements) defined by each Calibration Check Tube. Proper functioning of switches, tube illuminator lamp, power supplies, optics, displays, and mechanical components are also verified.

QBC Hematology Controls, normal and abnormal, are also available for daily quality control checks of the complete system, including the integrity of coating reagents and components of the blood tube devices.

Note: Optical, mechanical and electronic components of the Reader are calibrated at the factory and cannot be adjusted by the operator. In the event that target control values cannot be recovered, calibration adjustments must be made by an authorized service representative.

4.6.1 Using Calibration Check Tubes

At the time the QBC II Plus System is installed (and whenever a replacement Calibration Check Tube is required), tolerance limits for the Check Tube must be determined and recorded on the Package Insert supplied with the Tube (see Section 2.4.2). The resulting limits are then used by the Operator in the daily pre-test performance checks described below.

To perform the daily calibration checks:

- (1) Place the Reader in the "VEN" mode and insert the Venous Calibration Check Tube.
- (2) Referring to Figure 4.6, align the 1st interface (black-to-pale green) with the cursor and press "ENTER".
- (3) Continue reading the 2nd through the 6th interfaces in the same manner.
- (4) Record the Venous Cal Check values of the seven hematology parameters; then press the MODE button twice rapidly to obtain HB. Record the HB value and remove the Tube. Note: Record HB even if the check value is flashing.
- (5) Select the "CAP" mode, insert the Capillary Calibration Check Tube and repeat the reading procedure, including the 7th interface, as shown in Figure 4.6.

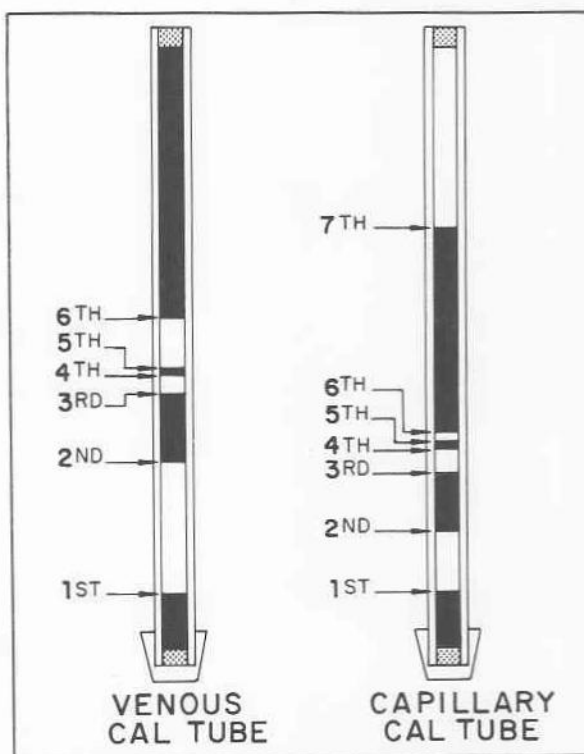


Figure 4.6. Interface Locations in QBC Calibration Tubes.

- (6) Record the Capillary Cal Check values of the seven parameters. Press the MODE button twice, then record the displayed HB value. Note: Record HB even though the check value is flashing.
- (7) Compare both sets of values (Ven and Cap) with the reference values and tolerances recorded on the Package Inserts of the Cal Check Tubes. If any value falls outside its tolerance limits, perform procedures (a) and (b) below in the order listed before requesting technical assistance.
 - (a) Carefully inspect the Check Tube yielding the out-of-tolerance value(s) for the presence of air bubbles between the black and white segments. Proceed to (b) if no bubbles are observed. If bubbles are present between segments, a replacement Calibration Check Tube should be ordered. Bubbles usually can be temporarily dislodged by shaking the tube down in the same manner as a clinical thermometer or by centrifuging for 5 to 10 seconds. If the bubbles are dislodged but the repeated Cal Check is still out-of-tolerance, proceed to (b).
 - (b) An out-of-tolerance value can be caused by parallax error due to incorrect focusing of the microscope. To minimize parallax error, align an interface in the Check Tube with the reticle arrow and observe the apparent alignment changes up or down while re-focusing the microscope. Determine the focus adjustment that gives the sharpest image of the arrow and interface, then repeat the tube-reading sequence.

Request Technical Assistance if the above procedures fail to correct the condition.

4.6.2 QBC Hematology Controls

QBC Hematology Controls (Catalog No. 4242) are available in refrigerated shipments, each containing a one-month supply of normal and abnormal material. Filling and tube preparation procedures with controls are the same as those for human blood. Detailed preparation and testing instructions are provided in the package insert of each control Kit, together with normal and abnormal assay values.

4.7 OPERATING PRECAUTIONS

- Power Connections: Connect the Reader and Centrifuge only to a 3-wire grounded A.C. outlet rated at the voltage and frequency specified on the data plate of the instrument.
- Calibration Checks: For reliable test results, be sure to observe the daily pre-test check procedures specified in 4.2 of this Section.
- Technique: Carefully observe the recommended blood collection, tube preparation, and test techniques described in Sections 6 and 7.
- Test Values: READINGS SHOULD NOT BE RECORDED FOR PATIENT EVALUATION UNLESS THE BLOOD TUBE EXHIBITS CLEAR COLOR DEMARCATIONS BETWEEN EVERY ADJACENT CELL LAYER. Consult "LIMITATIONS" in Section 8 for further details.

4.8 HAZARDS

The QBC II Plus System has been designed for maximum operator safety. In order to avoid hazards to personnel when using components of the system, observe the following basic safety rules:

Electrical

- Never remove the grounding prong from a power cord plug.
- Always unplug the power cord before attempting to perform authorized repair or service on any unit.
- If a power cord is damaged, have it replaced by a qualified service technician.

Blood Specimens

- Blood specimens should be handled with care, using accepted laboratory techniques. The use of protective laboratory gloves is recommended.
- Blood specimens may contain the Hepatitis B Virus or Human Immunodeficiency Virus (HIV) and should be handled with extreme care.
- Exercise care when handling QBC Blood Tubes. The blood tubes are made of glass and may break.

Section 5 MAINTENANCE AND SERVICE

5.1 INTRODUCTION

Maintenance and service to the QBC II Plus System that can be performed by the customer are limited to the procedures described in this Section. DO NOT ATTEMPT ANY OTHER SERVICE OR REPAIRS.

Appendix C contains a complete list of replacement parts and accessories for QBC II Plus. All listed items, including test disposables, can be ordered from your QBC Distributer. When ordering, be sure to include the full catalog or part number.

5.2 TECHNICAL ASSISTANCE AND REPAIR SERVICE

In the United States, the Technical Service Department of Becton Dickinson Primary Care Diagnostics provides unlimited telephone consultation through a toll-free number: 1-800-631-8064. Technical Service is staffed by a team of Medical Technologists who can, in many cases, resolve problems by providing expert technical guidance. For problems that cannot be resolved via telephone, Technical Service will provide one of several servicing alternatives. Outside the United States, technical assistance can be obtained through your QBC distributor or nearest Becton Dickinson and Company office.

DO NOT RETURN ANY COMPONENT OF THE SYSTEM WITHOUT SPECIFIC INSTRUCTIONS FROM THE TECHNICAL SERVICE DEPARTMENT.

5.3 MAINTENANCE AND CUSTOMER-SERVICEABLE PARTS

5.3.1 Reader Lubrication

In order to assure smooth movement of the tube holder mechanism over its full length of travel, the internal Lead Screw, Extension Shaft and Guide Rod should be lubricated approximately once each year. To gain access for lubrication, the top cover must be removed as follows:

- DISCONNECT THE POWER CORD.
- Referring to Figure 5.1, remove the rubber grommet from the Microscope.

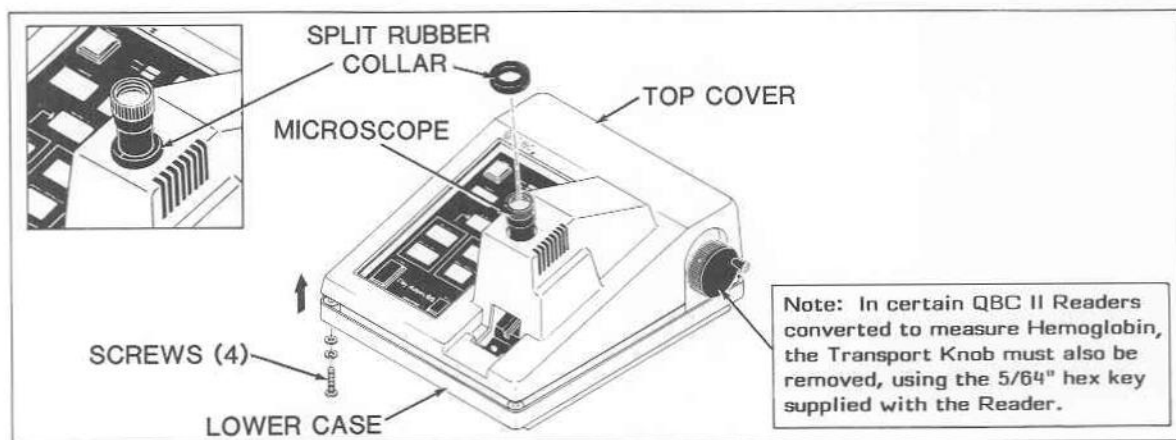


Figure 5.1. Top Cover Removal Details.

c) From the bottom of the Reader, remove the Phillips-head screws and washers from the four corners of the lower case. Then lift off the top cover.

Note: Removal of the top cover automatically activates a Safety Interlock Switch (see Figure 5.2) that cuts off electrical power to the Reader.

The Lead Screw, Extension Shaft and Guide Rod are shown in Figure 5.2. The recommended lubricant is Dow Corning Molykote Gn Paste, available from Becton Dickinson in a tube applicator, Catalog No. 4200-600-006. DO NOT USE OIL OR OTHER LIQUID LUBRICANTS.

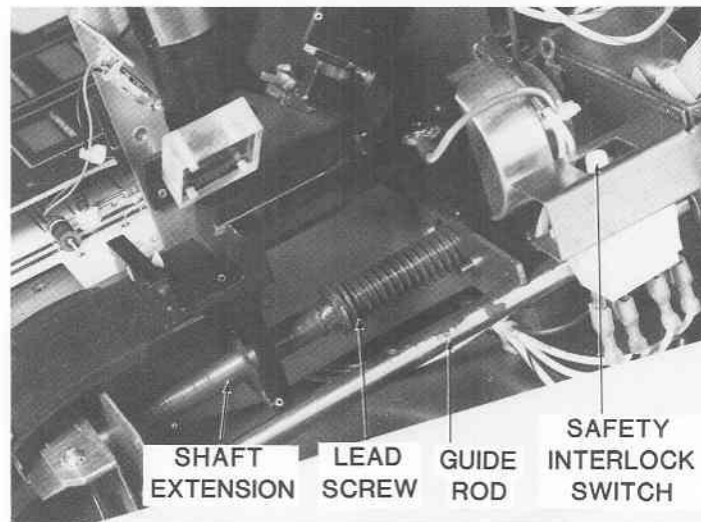


Figure 5.2. Lead Screw and Guide Rod (Top Cover Removed).

To lubricate the Lead Screw, apply small dabs of Molykote Gn paste at intervals along the complete length of the Lead Screw threads and Cylindrical Extension Shaft. Then rotate the screw $\frac{1}{4}$ turn, three times, each time applying dabs of Molykote Gn along its full length. To lubricate the Guide Rod, apply a very thin uniform film of Molykote Gn to the top and bottom surfaces of the Rod. After lubrication, move the mechanism back and forth against the front and back stops of the Lead Screw several times to work the lubricant into the Lead Screw threads and along the Guide Rod surface and Extension Shaft.

Referring to Figure 5.1, re-install the top cover and rubber microscope grommet.

5.3.2 Reader Internal Lamps

The Reticle Arrow, Illuminator and Tube Lamps are all operated under derated conditions in order to assure extended service life. Burnout of any of these lamps can be detected as follows:

- Reticle Arrow Lamp - when the reticle arrow is barely visible through the microscope.

- Tube Lamp (white light) - when an auxiliary light fails to appear after the first interface reading of a blood tube, making the 2nd interface difficult to locate. Lamp operation can be momentarily verified by pressing the "CLEAR" button.
- Illuminator Lamp - when the tube appears dark through the microscope.

A replacement for each lamp is supplied in the Spare Parts and Accessories Kit.

To gain access to the internal lamps, DISCONNECT THE POWER CORD. Remove the microscope grommet and top cover according to the procedures in Paragraph 5.3.1.

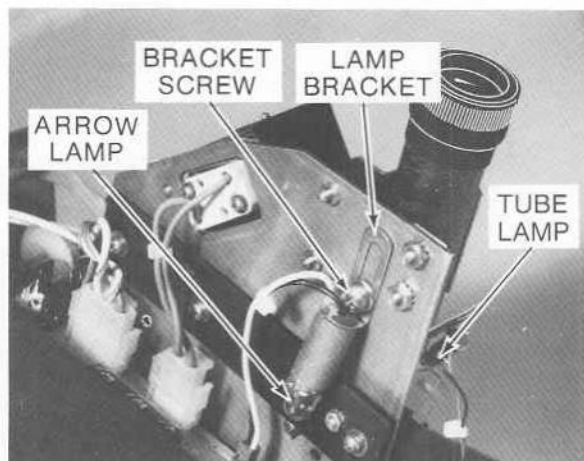


Figure 5.3. Reticle-Arrow Lamp Details.

a. Replacing Reticle Arrow (Cursor) Lamp

Referring to Figure 5.3, loosen the bracket screw, and pivot the Reticle Lamp Assembly forward. The lamp incorporates a bayonet-type base. Gently press and turn the bulb until the lamp springs free from its socket. Replace with a Catalog No. 2510-624-513 Reticle Arrow Lamp by pressing and turning the bulb into the Lamp socket. Wipe the bulb clean of fingerprints and smudges. Pivot the bracket assembly back. Before retightening the bracket screw, adjust the bracket so the filament of the lamp is in line with the reticle arrow.

Temporarily replace the cover. Reconnect the power cord, and press Power on. Check for uniform illumination of the reticle arrow, indicating correct adjustment of the lamp filament and bracket. Readjust as necessary. Then disconnect the power cord. Reinstall the top cover and microscope grommet.

b. Replacing Illuminator Lamp

Referring to Figure 5.4, loosen the wing nut and remove the cover from the illuminator assembly to expose the Illuminator Lamp (Figure 5.5). Pull the Illuminator Lamp from its socket. Replace with a Catalog No. 4227-602-000 Illuminator Lamp by inserting the base pins into the lamp socket. Be sure the lamp is seated straight in the socket. IMPORTANT: Wipe fingerprints and smudges from the bulb. Replace the cover and wing nut. Reinstall the top cover and microscope grommet.

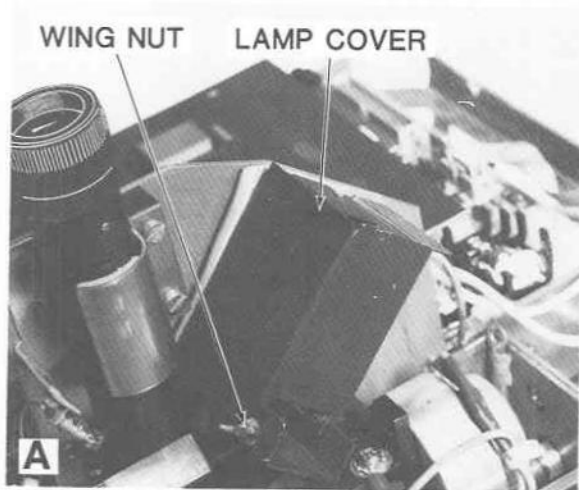


Figure 5.4. Illuminator Housing.

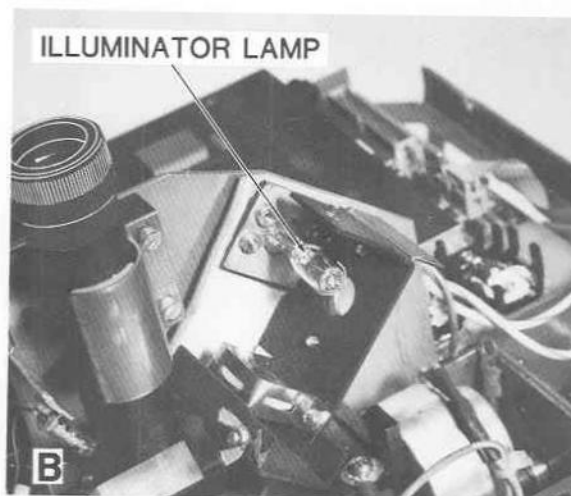


Figure 5.5. Illuminator Lamp and Socket.

c. Replacing Tube Lamp

To replace the tube lamp, the microscope must be loosened and moved up to provide access to the lamp (Figure 5.6).

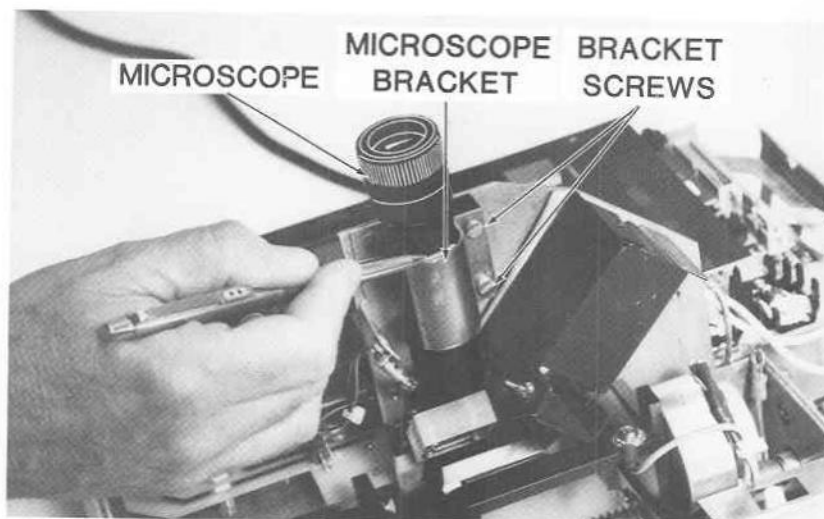


Figure 5.6. Tube Lamp and Microscope Bracket Details.

Before moving the microscope, scribe a pencil mark on the barrel at the top of the clamp as shown in Figure 5.6 so that the scope can be returned to its original position.

Loosen the two bracket screws; then slide the microscope up so that the Tube Lamp (Figure 5.7) can be removed. Pull the Lamp from its clip socket, and replace with a Catalog No. 2510-624-512 Tube Lamp.

Slide the microscope down until the pencil line is flush with the top of the barrel clamp; then tighten the clamp screws. Reinstall the top cover knob and microscope grommet.

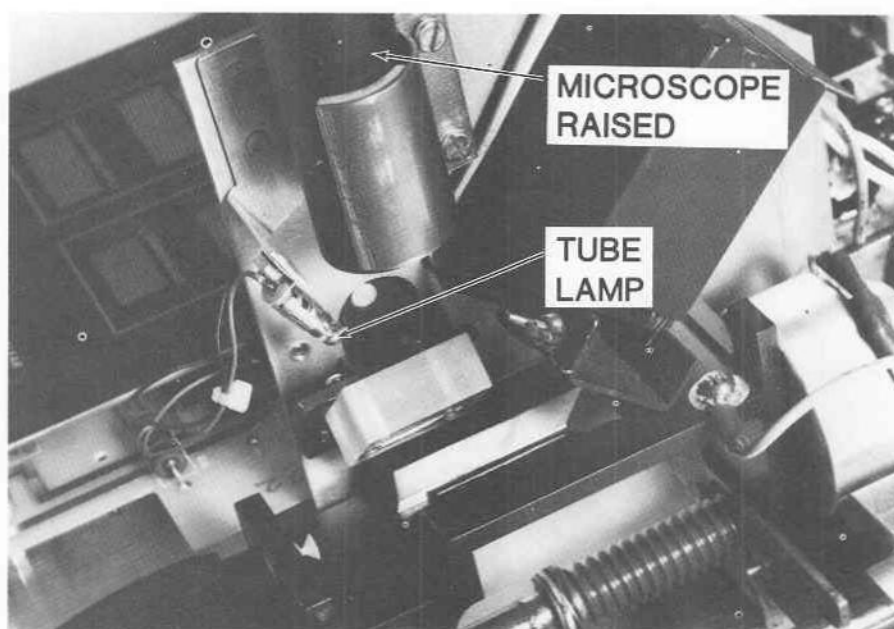


Figure 5.7. Tube Lamp, Showing Microscope in Raised Position.

5.3.3 Seven-Segment Readouts

Each digit of a panel readout consists of a seven-segment display (Figure 5.8) that plugs into sockets on a Main Printed Circuit Board. If a digit segment fails to light, the display digit can be replaced as described below.

- a) DISCONNECT THE POWER CORD.
- b) Remove the top cover from the Reader according to the procedures in Paragraph 5.3.1
- c) Referring to Figure 5.8A, from the right corners of the display panel, remove the two Phillips-head screws that mount the panel to the standoff posts.
- d) Lift and lay aside the display panel with attached POWER switch and wiring (Figure 5.8B). Do NOT disconnect the Power switch wires.

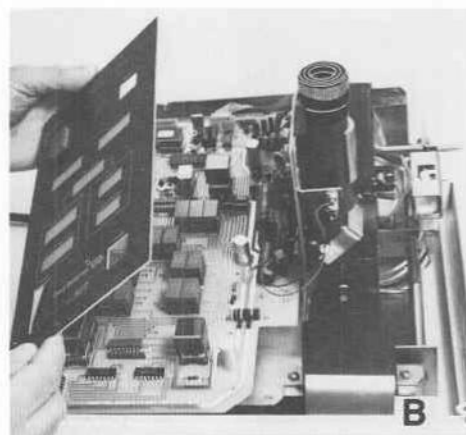
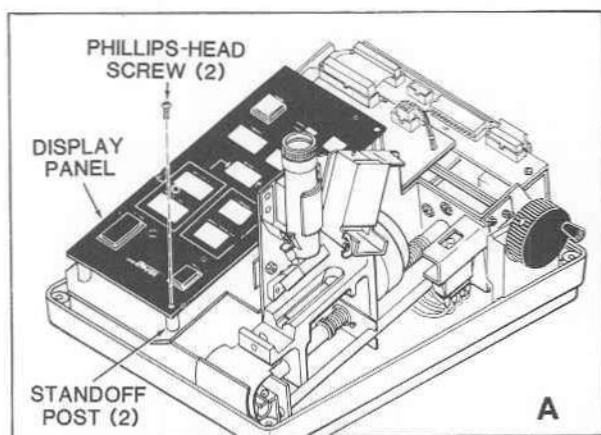


Figure 5.8. Removing Display Panel to Expose Main Circuit Board.

- e) Carefully extract the malfunctioning display digit from its pin sockets as shown in Figure 5.9.

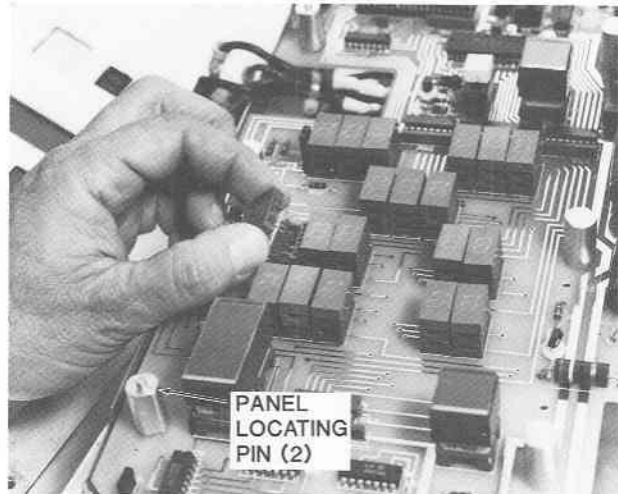


Figure 5.9. Extracting Seven-Segment Display Digit.

- f) Using a Catalog No. 2510-621-746 replacement display, orient the decimal dot down and, holding the display pins vertically over the socket, insert the pins of the display straight into the board socket. Do NOT bend or twist the display pins.
- g) Reinstall the display panel by replacing but not tightening the two Philips-head screws in the right corners of the panel (see Figure 5.8A). Adjust the panel so there is no interference between the panel cutouts and the MODE, ENTER and CLEAR switch buttons; then tighten the panel mounting screws.
- h) Replace the top cover and microscope grommet.

5.3.4 Reader POWER Switch

If the light in the POWER switch fails or the switch itself malfunctions, replace the switch assembly as described below.

- a) DISCONNECT THE POWER CORD.
- b) Remove the top cover of the Reader according to the procedures in Paragraph 5.3.1.
- c) Lift off the display panel with attached Power switch and push-on wire leads.
- d) Pry off the push-on connectors of the 4 wires from their terminals on the POWER switch (Figure 5.10).
- e) From the back of the display panel, compress the spring clips on both sides of the switch assembly and force the switch out through the front of the panel.
- f) Using a Catalog No. 4460-650-002 Power Switch, press the replacement switch through the front of the panel.

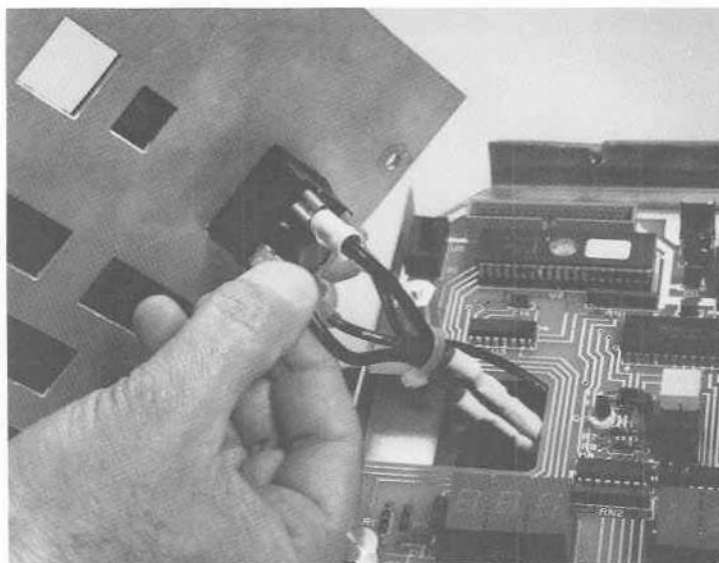


Figure 5.10. Disconnecting POWER Switch Wires from Switch Terminals.

- g) Connect the push-on connectors of the 4 switch wires to the switch terminals according to the wiring diagram in Figure 5.11. BE SURE THE WIRES ARE CONNECTED TO THE CORRECT SWITCH TERMINALS AND THE PUSH-ON CONNECTORS ARE PRESSED IN FULLY.
- h) Reinstall the display panel following the procedures in Step (g) of Paragraph 5.3.3.
- i) Replace the top cover and microscope grommet.

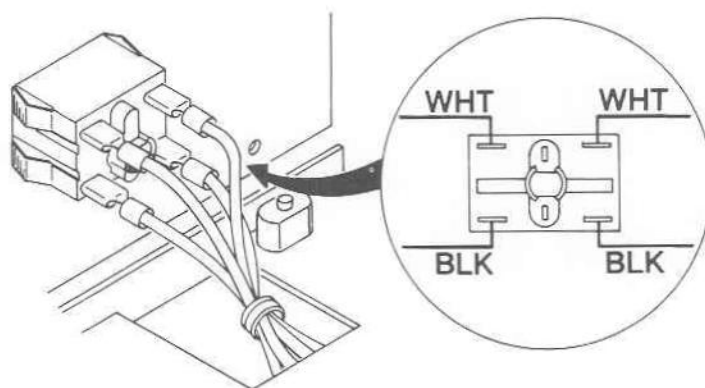


Figure 5.11. Power Switch Wiring Diagram.

5.3.5 Power Fuse

The Model 4452 QBC II Plus Reader incorporates a single main power fuse, located in the back of the instrument (Figure 5.12). The fuse has the following rating: 3 AG 1½ Amp Slo-Blo. Spare fuse are supplied with the Reader; additional fuse can be ordered from Becton Dickinson (Part No. 2510-623-814).

To replace a blown power fuse:

- 1) DISCONNECT THE LINE CORD.
- 2) Press the bottom of the white "FUSE" holder button located in the back of the Reader (Figure 5.12). The holder button will release from its housing along with the fuse.
- 3) Pull the blown fuse out of the holder button and insert the correct replacement fuse.
- 4) Insert the fuse and holder button into the housing and press to lock the holder in place.

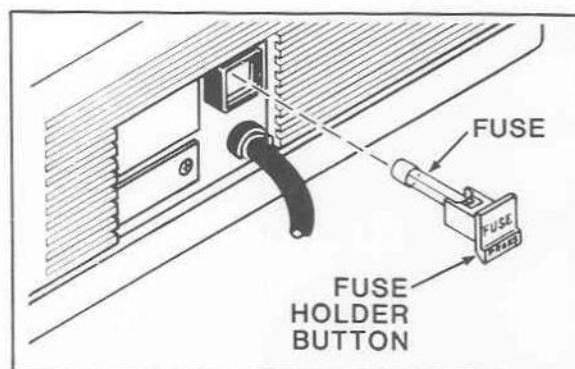


Figure 5.12. Main Power Fuse.

CAUTION
WHENEVER A REPLACEMENT FUSE BLOWS OUT, REQUEST TECHNICAL ASSISTANCE TO CORRECT AN INTERNAL ELECTRICAL SHORT CIRCUIT.

5.3.6 Reader Cleaning

a. Exterior Surfaces

Periodically clean the QBC II Plus Reader and QBC Centrifuge with a damp cloth moistened with soap and water or a mild liquid detergent solution. NEVER USE SOLVENTS OR STRONG ABRASIVE CLEANERS. Note: The Centrifuge rotor should only be cleaned only in accordance with specific instructions in the Centrifuge Operator's Manual.

b. Microscope Eyepiece

Clean the surface of the lens with optical tissue, a sable or camel's hair brush, or a liquid cleaner specifically recommended for optical glass.

c. Beam Splitter

With time, the Beam Splitter in the internal optics of the Reader may require cleaning in order to maintain clarity and brightness of the blood tube image. To gain access to the Beam Splitter:

- 1) Remove the top cover according to procedures in 5.3.1.
- 2) Loosen and slide up the microscope according to procedures in 5.3.2c in order to gain access to the Beam Splitter Block (Figure 5.13).

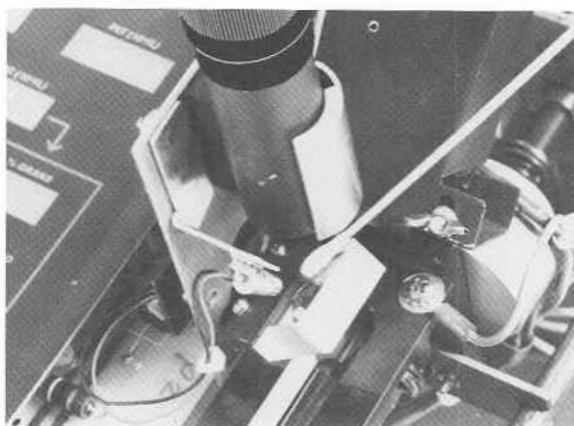


Figure 5.13. Cleaning Beam Splitter Block with Swab.

- 3) Clean the upper and lower surfaces of the Beam Splitter with a cotton swab. BE CAREFUL NOT TO SCRATCH THE POLISHED SURFACES. DO NOT DISASSEMBLE THE BEAM SPLITTER.
- 4) Lower the microscope to its correct position and tighten the bracket screws. Re-install the top cover and microscope grommet.

5.3.7 Reader Mechanical and Optical Checks

Operation of the tube holder and optics mechanisms of the Reader should be checked periodically in order to verify smooth movement and correct mechanical and optical alignment.

a. Tube Holder Movement

Turn the transport knob clockwise and counterclockwise several times while observing movement of the tube holder. The holder should travel in and out smoothly without excessive vertical or lateral bouncing or jumping.

Lubrication of the lead screw, extension shaft and guide rod may be necessary (see 5.3.1) if the tube holder mechanism does not move smoothly.

b. Tube Rotation

Insert one of the Calibration Check Tubes and focus the microscope by rotating the eyepiece. Observe the rotating tube through the microscope. There should be minimum blurring of the tube image when viewed through the scope. Externally, the tube should rotate smoothly, without excessive jumping or bouncing.

If the tube jumps or bounces excessively, the rubber drum roller on which the tube rests should be cleaned as follows: With the drum roller spinning, gently wipe the complete length of the roller with a cotton swab that has been dipped in isopropyl alcohol (Figure 5.14).

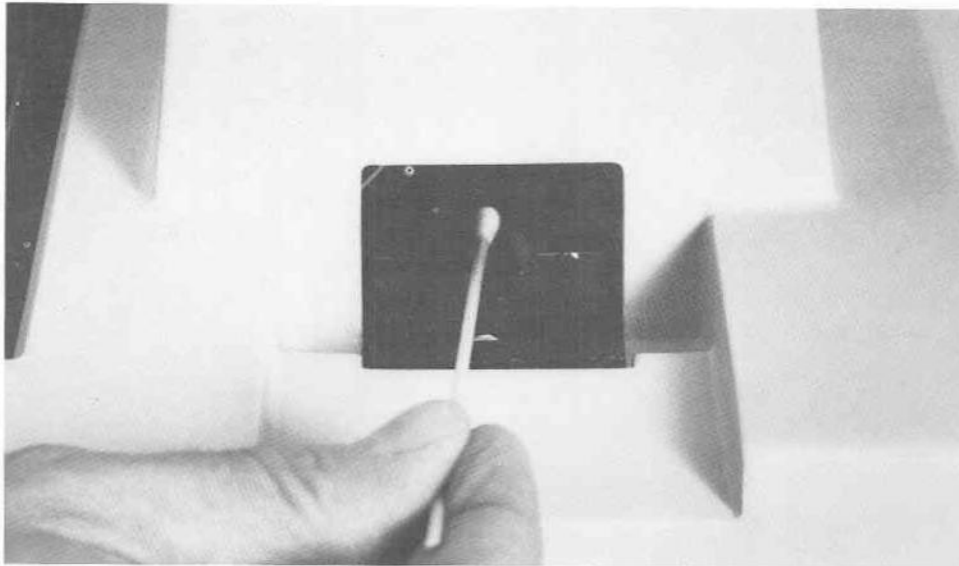


Figure 5.14. Cleaning Rotating Drum Roller with Cotton Swab.

c. Optics and Carriage Alignment

- 1) Turn the transport knob until the 1st interface of the Check Tube is aligned with the tip of the reticle arrow.
- 2) Observe the position of the tip of the arrow in relation to the tube. The tip should overlap the tube within the limits shown in Figure 5.15; however the overlap should not exceed $1/4$ the diameter of the tube.

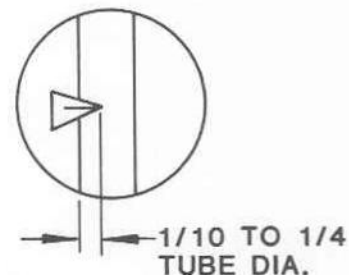


Figure 5.15. Overlap Tolerance of Reticle Arrow.

- 3) While moving the tube to the other end, observe the overlap of the arrow tip. The overlap should be within the limits shown in Figure 5.15.
- 4) If overlap is not within the limits shown in Figure 5.15, Request Service for alignment of the reticle arrow and optics.

5.3.8 Repairs to QBC Centrifuge

The Operator's Manual supplied with the QBC Centrifuge contains detailed instructions and procedures for performing the customer-serviceable repairs and parts replacements.

5.3.9 Replacing O-rings in QBC Pipetter

Leakage of blood or failure of the QBC Pipetter to aspirate blood to within ± 1 millimeter of the fill line of the QBC Venous Tube (see discussion in 4.5 of Section 4) indicates that O-ring seals in the Pipetter may be worn and should be replaced. A spare set of three O-rings, and O-ring grease are supplied with the Pipetter.

To replace the O-rings, refer to Figure 5.16 and disassemble the Pipetter as follows:

- (a) Unscrew the plastic Barrel, with attached metal Coupling, from the Handle of the Pipetter. Then unscrew the Coupling from the Barrel.
- (b) Referring to Figure 5.17, remove shaft O-ring "A", barrel O-ring "B", and coupling O-ring "C".
- (c) Using the spare set of O-rings, apply a heavy coat of grease to replacement O-ring "A" and press the O-ring into the shaft cavity of the Barrel.
- (d) Lightly grease replacement O-ring "B" and slip the O-ring over the threaded end of the Barrel.
- (e) Lightly grease replacement O-ring "C" (small O-ring) and insert into the Coupling.
- (f) Reassemble the Coupling to the Barrel.

CAUTION

When turning the metal Coupling onto the small threaded end of the plastic Barrel, FINGER-TIGHTEN ONLY. Overtightening may cause the threaded end of the Barrel to break.

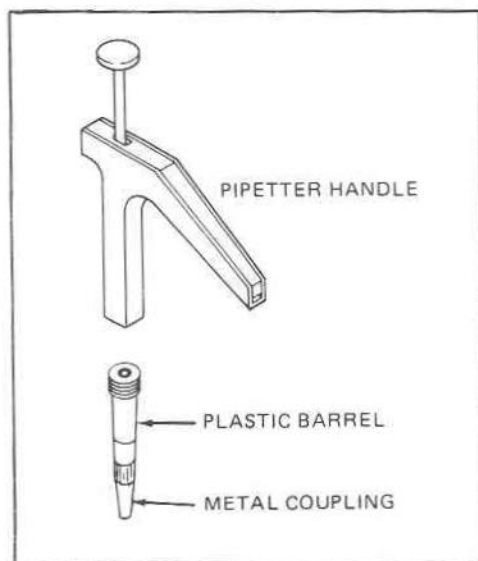


Figure 5.16.
Disassembling Barrel and
Coupling From Pipetter Handle.

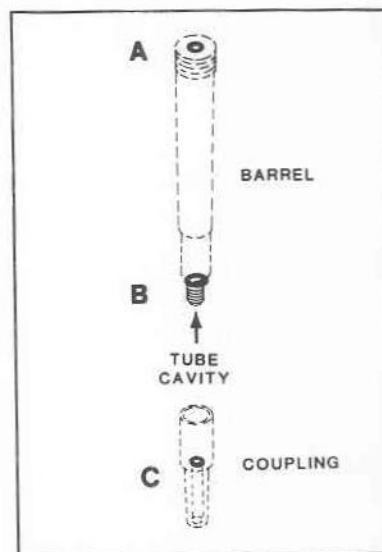


Figure 5.17.
Disassembled Barrel and
Coupling O-Rings.

- (g) After reassembly, insert the flame-polished end of a QBC Tube (end nearest two red lines) fully into the Coupling and Barrel, then remove and wipe the end of the tube. Repeat several times to remove any excess grease from O-ring "C".
- (h) Remove the Coupling from the Barrel and, using a tissue, clean out any grease from the Tube Cavity (see Figure 5.17). IMPORTANT: Excess grease forced inside the bore of a QBC Venous tube can cause the float to stick and fail to descend during centrifugation.
- (i) Reassemble the Coupling and Barrel to the Pipetter handle.

5.4 TROUBLESHOOTING

When unexplained difficulties are encountered in obtaining accurate test results, blood tube preparation and reading technique should be reviewed for possible procedural errors as the first step in troubleshooting. Step-by-step blood collection, tube preparation, and assay procedures are detailed in Sections 5 and 6 of this Manual. Special precautions and requirements regarding laboratory temperature (90°F maximum), freshness of sample, tube handling, and assay timing are critical to good cell banding and accurate test results. Once proper technique has been verified, other causes may then be considered.

As discussed in Section 8, certain blood specimens may fail to produce clearly readable cell layers in the QBC tube despite flawless preparation technique. These partially or totally unreadable tubes may be due to pathologic conditions or chemotherapy, where changes in cell density, fragility or morphology may prevent testing by the QBC method. Such specimens must be tested by other means.

The QBC II Plus Reader has been designed for maximum reliability and consistent day-to-day performance when operated and maintained according to specified directions. Malfunctions or out-of-specification performance of the instrument can quickly be detected through daily reading of the Calibration Check Tubes. Other mechanical, electrical and optical malfunctions should be immediately evident during routine use. With the QBC Centrifuge, deviations from design specifications can be identified by performing the Calibration Checks recommended in the Centrifuge Operator's Manual.

In the United States, assistance in correcting equipment malfunctions can be obtained by calling the Technical Service Department of Becton Dickinson Primary Care Diagnostics: 1-800-631-8064. Outside the United States, contact your QBC distributor or nearest Becton Dickinson and Company office.

Section 6
SPECIMEN COLLECTION AND PREPARATION FOR TESTING

WARNING
BLOOD SPECIMENS MAY CONTAIN THE HEPATITIS B
VIRUS OR HUMAN IMMUNODEFICIENCY VIRUS (HIV).
ALWAYS HANDLE BLOOD SPECIMENS AS POTENTIAL
BIOHAZARDS CAPABLE OF TRANSMITTING INFECTION.

6.1 VENOUS BLOOD

Venous specimens should be collected only into the anticoagulants disodium or tri-potassium ethylenediamine-tetraacetate (EDTA).

6.1.1 Collection Procedures

- (a) Before collecting blood, clean hands thoroughly with a laboratory-approved antiseptic. Use only clean glassware and sterilized collecting instruments. Before venipuncture, clean the skin area with an antiseptic agent.
- (b) Draw venous blood with a VACUTAINER® Brand Blood Collection Tube* or other blood-drawing device containing EDTA. To assure an acceptable blood-to-anticoagulant ratio, fill the collection tube to at least 2/3 of its total fill volume. Remove the collection needle and destroy after use.
- (c) Thoroughly mix the blood with the EDTA anticoagulant. IF SMALL CLOTS ARE OBSERVED, DISCARD THE SPECIMEN AND OBTAIN A FRESH ONE.

6.1.2 Anticoagulants

Blood for QBC II Plus venous tests must be anticoagulated only with disodium or tri-potassium EDTA. DO NOT USE OTHER ANTICOAGULANTS.

6.1.3 Interfering Substances

- Hemolysis: Tests should not be performed on visibly hemolyzed blood specimens.
- Bilirubin: No effects on test results have been observed at bilirubin concentrations up to 8.5 mg/dl.⁸
- Coumadin: Coumadin anticoagulant therapy has been shown to have no clinically significant effect on performance.⁸
- Doxorubicin: Treatment with the anthracyclic drug Doxorubicin does not appear to interfere with the QBC method.⁸
- Drugs: The effects of other potentially interfering drugs and their metabolites on QBC hematology tests have not yet been established.^{9,10}

*Product of Becton Dickinson Vacutainer Systems, Rutherford, N.J.

6.1.4 Specimen Storage and Stability

After blood collection, anticoagulated venous specimens may be held at a room temperature of 68° to 90°F (20° to 32°C) for the times indicated below.

- 90 Minutes from blood collection, provided all QBC hematology parameters, including the Platelet Count, are required. Note: Specimens older than 90 minutes may yield falsely elevated Platelet Counts. After centrifugation, QBC tubes may be tested any time within 4 hours. (See Assay Timing in Section 7.3.4 of Test Procedures for additional details.)
- 4 Hours from blood collection, provided QBC hematology parameters, except the Platelet Count, are required. After centrifugation, tubes may also be held for 4 hours prior to reading.

6.2 CAPILLARY BLOOD

Fill QBC Capillary-Blood Tubes directly from a finger puncture. QBC Capillary-Blood Tubes contain dry anticoagulant coatings and must be mixed after filling as described in Section 7.3.3. of Test Procedures.

6.2.1 Collection Procedures

- (a) The finger to be punctured must not be cyanotic or edematous. If cyanotic or cold, immerse in warm water for 3 to 5 minutes or apply a moist compress or warm pack before puncturing.
- (2) Clean the finger area with an antiseptic agent and wipe dry.
- (3) Puncture the finger with a sterile lancet, wipe away the first drop of blood, and immediately collect the next drop or two directly in the QBC Capillary Tube. Specimens taken after the first several drops may yield lower platelet counts, since the platelets may adhere to the wound site or may aggregate in the blood drop.
- (4) Slight pressure may be applied some distance from the finger puncture. Avoid squeezing the puncture area to prevent diluting the blood with tissue fluid.

6.2.2 Anticoagulants

QBC Capillary Tubes are internally coated with sodium heparin and di-potassium EDTA.

6.2.3 Interfering Substances

See Paragraph 6.1.3 under Venous Blood.

6.2.4 Stability of Filled QBC Capillary Tube

Filled QBC Capillary Tubes should be mixed and centrifuged promptly after blood collection. Consult "ASSAY TIMING" in of Section 7 for additional details.

Section 7
TEST PROCEDURES

7.1 MATERIALS PROVIDED

The QBC II Plus System consists of the following instruments and accessories for performing centrifugal hematology tests:

- QBC II Plus Reader;
- QBC Centrifuge;
- QBC Work Station;
- QBC Venous-Blood Pipetter.

7.2 MATERIALS REQUIRED, BUT NOT PROVIDED

The following disposables are required for QBC hematology tests:

- QBC Venous-Blood Tubes;
- QBC Capillary-Blood Tubes.

7.3 CENTRIFUGAL HEMATOLOGY TESTS

7.3.1 Pre-Test Conditions

- a) QBC Tube Tray, uncovered and placed in the Work Station. Note: QBC BLOOD TUBES ARE SENSITIVE TO MOISTURE AND LIGHT. REMOVE TUBES ONE BY ONE FROM THEIR OPAQUE VIAL, AND RE-STOPPER THE VIAL EACH TIME A BLOOD TUBE IS REMOVED. QBC Blood Tubes are stable for 30 days after first opening a vial of tubes.
- b) Laboratory Temperature: Perform QBC centrifugal hematology tests at 68° to 90°F (20° to 32°C). If blood tubes are tested at temperatures below 68°F (20°C), hematology results may be erroneously high; if tested above 90°F (32°C), interfaces in the blood tube may become blurred and unreadable.
- c) Specimen:
 - For QBC Venous-Blood Tests: Use well-mixed, EDTA-anticoagulated blood at 68° to 90°F (20°C to 32°C). For venous blood test procedures, see 7.3.2.

IMPORTANT

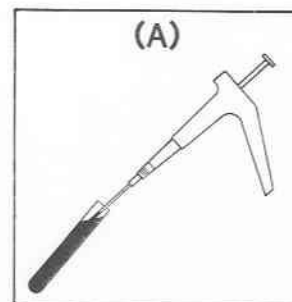
VENOUS BLOOD TUBES MUST BE PREPARED WITHIN 90 MINUTES OF BLOOD COLLECTION IF ALL QBC PARAMETERS, INCLUDING THE PLATELET COUNT, ARE REQUIRED. When the Platelet Count is not needed, 4 hours can elapse before the blood tube is prepared.

- For QBC Capillary-Blood Tests: use fresh blood collected from a free flowing finger puncture. For capillary blood test procedures, see 7.3.3.

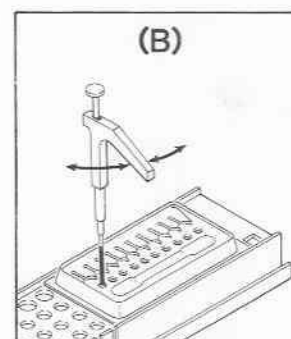
7.3.2 Test Procedures: QBC VENOUS-BLOOD TUBES

STEP 1. FILL AND SEAL BLOOD TUBE

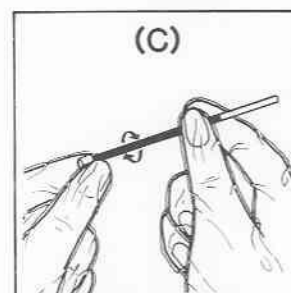
Insert the end of the Tube nearest the red lines into the Pipetter. Push the Tube in until it seats snugly inside Pipetter barrel. Depress the plunger of the Pipetter, then insert the distal end of the Tube into a specimen of well-mixed anticoagulated venous blood (A). Slowly release the plunger of the Pipetter to fill the Tube. With the Tube horizontal, check that the blood level is within ± 1 mm of the black fill line.



Wipe any blood from the surface of the Tube with lint-free tissue. Press the distal end of the Tube firmly into a closure in the tube tray (B). Twist the Pipetter slightly to be sure that the closure remains on the Tube when the Pipetter and Tube are lifted.

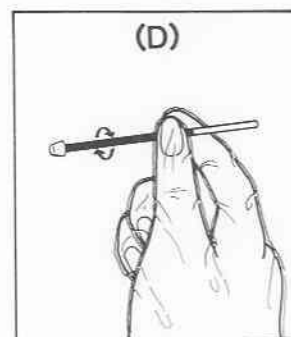


Remove the Tube from the Pipetter. Manually twist and firmly push on the closure to form a leak-tight seal (C). Be sure the closure is on straight. FAILURE TO SEAT THE CLOSURE STRAIGHT MAY RESULT IN BLURRED INTERFACES.



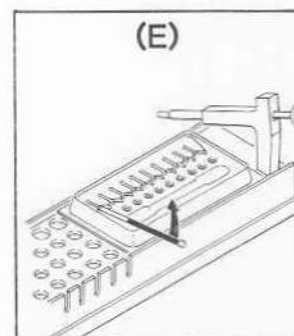
STEP 2. ROLL TUBE BETWEEN FINGERS TO MIX

Gently roll the Tube between the fingers at least 10 times or for at least 5 seconds, keeping the unsealed end slightly above the horizontal (D). PROMPTLY PROCEED TO STEP 3.



STEP 3. INSERT FLOAT INTO BLOOD TUBE

Slide the unsealed end of the Tube over the tip of the pre-positioned float (E) and push until the float is inside the Tube as far as possible. Gently lift the closure end of the Tube until the float releases from its tray slot. Raise the unsealed end of the Tube slightly above horizontal to prevent the float from falling out. If necessary, press the end of the float against a clean surface until it is inside the Tube. NOTE: NEVER TOUCH FLOATS WITH THE FINGERS. USE THE FORCEPS TO HANDLE LOOSE OR DROPPED FLOATS.



Note: After inserting the float, a between-step delay is permitted for batching blood specimens, provided tubes are stored vertically, closure down in the Work Station. A maximum of 20 minutes is allowed between insertion of the float and completion of Centrifugation in Step 4.

STEP 4. CENTRIFUGE FOR 5 MINUTES

Place the blood tube(s) on the rotor of the QBC Centrifuge by inserting the open end under the flange of the rotor nut, then lowering the tube into the rotor slot. Position the tube closure against the outer rim of the rotor. If an odd number of tubes are being centrifuged at one time, use an empty tube (with closure and float) for balancing. Secure the rotor cover and press the centrifuge lid down until it latches. Start the QBC Centrifuge. When centrifugation is complete, PROMPTLY REMOVE THE TUBES FROM THE ROTOR.

Time Delay Between Completion of Centrifugation and Tube Reading: Centrifuged QBC Tubes are stable for up to 4 hours prior to reading, provided they are stored vertically (closure down) in the Work Station and away from heat and intense light.

IMPORTANT:

- Excessive heat may disturb cell layer interfaces in the centrifuged blood tube. Avoid picking up or handling the spun tube below the plasma column. Do not place centrifuged tubes on warm surfaces or under intense light.
- Do NOT leave blood tubes on the rotor after centrifugation. Remove and read immediately, or store in a vertical, closure-down position to preserve distinct cell layers.
- Do not twist or move tube closures after centrifugation.

STEP 5. READ TUBES AND RECORD TEST VALUES

Note: Read the QBC tube as soon as possible after insertion in the Reader, since the cell interfaces may become slightly blurred from prolonged exposure to heat.

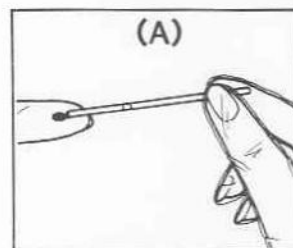
Be sure the "VEN" key is pressed and the "VEN" indicator light is On. Insert the centrifuged tube, closure end first, into the Reader. PROMPTLY read the six interfaces in the blood tube as shown in Section 4.3.2. Record the seven hematology values displayed in the readouts. To obtain the Hemoglobin value, rapidly press the MODE button twice.

Remove the tube and test the next blood tube. Note: Pressing "ENTER" in the next test will erase all values from the previous test.

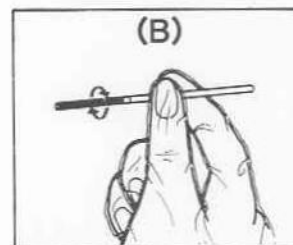
7.3.3 Test Procedures: QBC CAPILLARY-BLOOD TUBES

STEP 1. FILL AND MIX TUBE

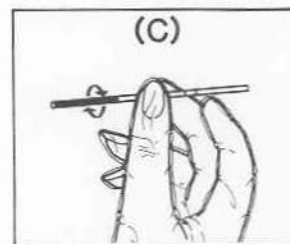
From the end of the tube nearest the two black lines, fill the tube with finger puncture blood to a level between the lines (A). With lint-free tissue wipe any blood on the outside of the tube, being careful not to draw any specimen from the tip of the tube.



Keeping the tube nearly horizontal, roll the tube between the fingers several times to mix the blood with the anticoagulant coating (B).

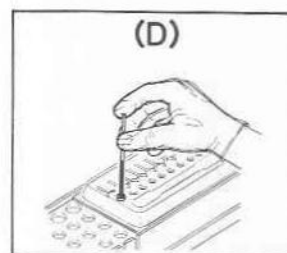


Turn the tube around and tilt, allowing the blood to flow to the opposite end of the Tube (C). Roll the tube between the fingers at least 10 times or for at least 5 seconds to mix the blood with the Potassium Oxalate and Acridine Orange coating. PROMPTLY PROCEED TO STEP 2.

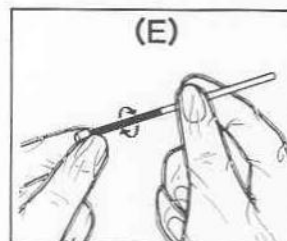


STEP 2. SEAL TUBE AND INSERT FLOAT

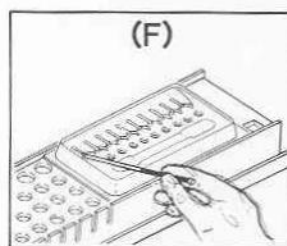
Place the index finger over the end of the Tube nearest the fill lines, and insert the distal end into a Closure in the tube tray (D).



Manually twist and firmly push on the closure to form a leak-tight seal (E). Be sure the closure is on straight. FAILURE TO SEAT THE CLOSURE STRAIGHT MAY RESULT IN BLURRED INTERFACES.



Slide the unsealed end of the Tube over the tip of the pre-positioned float (F) and push until the float is inside the Tube. Gently lift the closure end of the Tube until the float releases from its tray slot. Raise the unsealed end of the Tube slightly above horizontal to prevent the float from falling out. If necessary, press the float against a clean surface to push the end into the Tube. NOTE: NEVER TOUCH FLOATS WITH THE FINGERS. USE THE FORCEPS TO HANDLE LOOSE OR DROPPED FLOATS.



Note: After inserting the float, a between-step delay is permitted for batching blood specimens, provided tubes are stored vertically, closure down in the Work Station. A maximum of 20 minutes is allowed between insertion of the float and completion of Centrifugation in Step 3.

STEP 3. CENTRIFUGE FOR 5 MINUTES

Place the blood tube(s) on the rotor of the QBC Centrifuge by inserting the open end under the flange of the rotor nut, then lowering the tube into the rotor slot. Position the tube closure against the outer rim of the rotor. If an odd number of tubes are being centrifuged at one time, use an empty tube (with closure and float) for balancing. Secure the rotor cover and press the centrifuge lid down until it latches. Start the QBC Centrifuge. When centrifugation is complete, PROMPTLY REMOVE THE TUBES FROM THE ROTOR.

Time Delay Between Completion of Centrifugation and Tube Reading: Centrifuged QBC Tubes are stable for up to 4 hours prior to reading, provided they are stored vertically (closure down) in the Work Station and away from heat and intense light.

IMPORTANT:

- Excessive heat may disturb cell layer interfaces in the centrifuged blood tubes. Avoid picking up or handling spun tubes below the plasma column. Do not place centrifuged tubes on warm surfaces or under intense light.
- Do NOT leave blood tubes on the rotor after centrifugation. Remove and read immediately, or store in a vertical, closure-down position to preserve distinct cell layers.
- Do not twist or move the tube closure after centrifugation.

STEP 4. READ TUBES AND RECORD TEST VALUES

Note: Read the QBC tube as soon as possible after insertion in the Reader, since the cell interfaces may become slightly blurred from prolonged exposure to heat.

Be sure the "CAP" key is pressed and the indicator light is On. Insert the centrifuged tube, closure end first, into the Reader. PROMPTLY read the seven interfaces in the blood tube as shown in Section 4.3.2. Record the seven hematology values displayed in the readouts. To obtain the Hemoglobin value, rapidly press the MODE button twice.

Remove the tube and test the next blood tube. Note: Pressing "ENTER" in the next test will erase all values from the previous test.

7.3.4 Assay Timing (Blood Tube Stability)

To accommodate individual laboratory routines and to permit batch testing, the between-step delays noted previously in 7.3.2 and 7.3.3 and summarized below can be made without affecting test results.

• Venous Blood Tests

- a) Between Blood Collection and Completion of Centrifugation:
90 minutes for all hematology parameters, including the Platelet Count and Hemoglobin;
or
4 hours for all hematology parameters, EXCEPT THE PLATELET COUNT.
- b) Between Float Insertion and Completion of Centrifugation:
20 minutes maximum, provided the above times are not exceeded.
- c) From Completion of Centrifugation to Tube Reading:
4 hours, provided blood tubes are stored vertically with the closure down.

- Capillary Blood Tests

- a) From Finger Puncture Collection into the QBC Capillary-Blood Tube to Insertion of the Float: perform all preparation steps promptly.
- b) Between Float Insertion and Completion of Centrifugation:
20 minutes maximum.
- c) From Completion of Centrifugation to Tube Reading:
4 hours, provided blood tubes are stored vertically with the closure down.

7.3.5 Test Notes

- a. Protecting Blood Tubes

KEEP QBC TUBES TIGHTLY STOPPERED IN THEIR OPAQUE GLASS VIAL WHEN NOT IN USE. Remove tubes one by one as needed. Be sure to re-stopper the vial each time. Do NOT remove the strip of desiccant from the vial of tubes.

Store QBC Tubes in their sealed vial in a dark, dry place at 60° to 90°F (16° to 32°C). Protect from moisture, direct light and heat.

- b. Fill Level in Venous-Blood Tubes

If the Pipetter fails to aspirate blood to within ± 1 mm of the black fill-line on the QBC Venous Blood Tube, discard the Tube and prepare a fresh Tube. NEVER ATTEMPT TO EMPTY AND REFILL THE SAME BLOOD TUBE. If a fill problem persists, the Pipetter O-rings are most likely worn or faulty. Consult the O-ring replacement procedures in Section 5.3.9. As a temporary measure in the event the Pipetter is defective, Venous Tubes can be filled manually by capillary action.

If the plasma level in a spun QBC Venous Blood Tube is below the lowest red indicator line, blood was lost through leakage or evaporation; if above the top red line, too much blood was probably aspirated during fill. VENOUS BLOOD TUBES SHOULD NOT BE TESTED UNLESS THE PLASMA LEVEL FALLS BETWEEN THE TWO RED INDICATOR LINES.

7.4 CALIBRATION DETAILS

Daily use of the Calibration Check Tubes, as described in Section 4.6.1, will ensure that the QBC II Reader is operating within factory-set tolerances.

7.5 QUALITY CONTROL

Daily testing with QBC Hematology Controls (Catalog No. 4242) is recommended in order to verify performance of the complete QBC II Plus System, including blood tubes. See Section 4.6.2.

The results of QBC II centrifugal hematology tests with whole blood should be compared periodically with those obtained by standard reference methods. The reference procedures on the following page are recommended.

<u>Parameter</u>	<u>Reference Method</u>
HCT	Centrifugal Microhematocrit
WBC	Impedance Cell Counter
GRAN	100-Cell Manual Differential Count*
LYMPH/MONO	100-Cell Manual Differential Count**
PLT	Phase Microscopy or Impedance Cell Counter
HB	Cyanmethemoglobin Method ¹⁴

Note: Request service if the performance is not within acceptable correlation limits.

*Manual differential count of Granulocytes should include the sum of neutrophils, eosinophils and basophils.

**Manual differential count should include the sum of lymphocytes and monocytes.

Section 8 SYSTEM PERFORMANCE

8.1 TEST RESULTS

8.1.1 Digit-Decimal Format

Hematology values generated by the QBC II Plus Reader are displayed on the instrument readouts in the following decimal formats and units:

• Hematocrit (HCT)	XX.X	%	• Grans (rel.)	XX	%
• Hemoglobin (HB)	XX.X	g/dL	• Grans (abs.)	XX.X	10 ⁹ L
• Platelets (PLT)	XXX	10 ⁹ L	• Lymph/Mono (rel.)	XX	%
• WBC	XX.X	10 ⁹ L	• Lymph/Mono (abs.)	XX.X	10 ⁹ L

To convert QBC Hematocrit and Hemoglobin test results to S.I. (standard international) units, perform the following:

- Multiply QBC Hematocrit (%) by 0.01 to obtain Hematocrit (ratio);
- Multiply QBC Hemoglobin (g/dL) by 0.155 to obtain Hemoglobin in mmol/L.

When irregularities are detected in length measurements, tube-reading techniques or computed values, the Reader will automatically display a flashing alphanumeric flag and the test will be aborted (see Section 4.3.5). In such cases, no test results or only partial results will be displayed.

8.1.2 Interfaces and Cell Layer Colors

Through the microscope of the QBC II Plus Reader, interfaces between layers in the rotating blood tube should appear well defined and perpendicular to the longitudinal axis of the tube. READINGS SHOULD NOT BE MADE UNLESS THERE ARE CLEAR COLOR DEMARCATIONS BETWEEN EVERY ADJACENT CELL LAYER.

While layer colors may vary somewhat, they should be within the general family of colors previously described.

IMPORTANT: If the three expanded cell layers of the buffy coat appear greenish in color when viewed in the Reader, it usually indicates deterioration of the Acridine Orange coating.

8.1.3 Absent or Unclear Cell Layers

Under certain hematologic and pathologic conditions, the orange-yellow layer of Granulocytes may fail to form, or the lower boundary may be so poorly defined that a clear interface cannot be identified. The condition occurs when the specific gravity of the red cells shifts toward that of the granulocytic leukocytes, causing the red cells and granulocytes to intermingle.

In QBC tubes exhibiting red-cell and granulocyte intermingling, it has been determined that a large proportion exhibit an abnormal MCV, abnormal red cell distribution width (RDW), or other red-cell morphologic anomaly. In some blood specimens, the granulocyte layer may be totally absent or poorly defined despite normal red cell indices and morphology.

A missing granulocyte layer can be easily detected by the transition from the light red layer immediately into the green Lymph/Mono layer, as shown in Figure 8.1.

Should interface readings be inadvertently made where the granulocyte layer is absent, one less than the required number of cell layers (and interfaces) will be present and the Reader will not display test values.

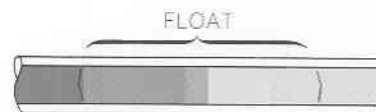


Figure 8.1. QBC Tube With Missing Granulocyte Layer.

8.1.4 Dark Band Formation Between Gran and Lymph/Mono Layers

The appearance of a thin-to-heavy dark red band (Figure 8.2) between the GRAN layer and LYMPH/MONO layer is not uncommon. Blood tubes exhibiting dark banding can be tested, provided a clear demarcation exists between the GRAN layer and the bottom of the dark band. When reading the 4th interface in dark-banded tubes, always align the arrow tip at the bottom of the dark band, i.e., at the interface between the orange-yellow GRAN layer and the dark band.

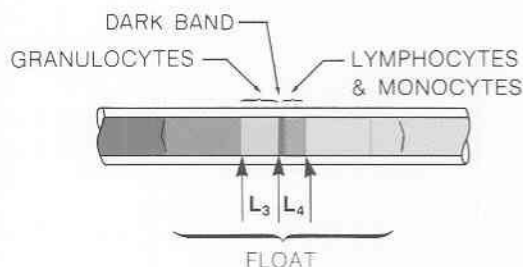


Figure 8.2. QBC Tube With Dark Band Formation Between GRAN and LYMPH/MONO Layers.

8.1.5 Cell Accumulations on Top of Float

In some blood tubes, accumulations of fluorescing cells may be seen adhering to the top and sides of the float while the platelet-to-plasma interface is being read. This appears to be related to the age and conditions of the sample. Studies have shown that the effect is not significant in specimens that are less than 90 minutes old. Therefore, it is important that the limits specified under "Assay Timing" in Section 7 not be exceeded.

8.1.6 Blurred Interfaces

Blurred or fuzzy interfaces—ranging from mild to severe—may result from entrapped lint particles, an improperly-seated closure, or when ambient room temperature exceeds the recommended 90°F (32°C) upper limit. Note: QBC tests must not be run in areas where the temperature exceeds 90°F.

Rotation of the blood tube in the Reader tends to optically average waviness or irregularities that may exist between cell layer boundaries, causing them to appear as straight, "readable" interfaces. As wavy conditions or irregularities increase, the visual effect in the rotating tube is one of color blending between boundaries or blurring. WHEN EXTREMELY FUZZY OR DIFFICULT-TO-READ INTERFACES ARE OBSERVED, THE SPECIMEN SHOULD BE TESTED BY ANOTHER METHOD.

8.2 OPERATING RANGES

Venous- and capillary-blood parameters measured by the QBC II Plus Reader are valid over the following range of values:

- Hematocrit 25 - 55 %
- Hemoglobin 5.0 - 20.0 g/dL
- White Cell Count 2.0 - 30.0 ($\times 10^9/L$)
- Gran 1 - 99 %; 0.02 - 29.7 $\times 10^9/L$ cells (over a WBC of 2.0 - 30.0 $\times 10^9/L$)
- Lymph/Mono 1 - 99 %; 0.02 - 29.7 $\times 10^9/L$ cells (over a WBC of 2.0 - 30.0 $\times 10^9/L$)
- Platelet Count 80 - 600 ($\times 10^9/L$)

If the specimen yields test values outside these ranges, results should be confirmed by alternative methods.

8.3 LIMITATIONS OF THE PROCEDURE

QBC Granulocyte and Lymphocyte/Monocyte counts are not intended to replace the conventional manual differential white cell count. Some disease states are characterized by the presence of abnormal white cell types and yet may display normal quantitative relationships of Granulocytes to Lymphocytes/Monocytes. Due to grouping of the white cell subpopulations by the QBC method, the System cannot discriminate between normal and abnormal cell types and may not indicate the presence of disease states where the number of certain white cell types may be abnormal (e.g., eosinophilia).

QBC tests must be performed in a temperature environment of 68° to 90°F (20° to 32°C). If blood tubes are tested at temperatures below 68°F (20°C), results may be erroneously high; if tested above 90°F (32°C), interfaces in the blood tube may become blurred and difficult to read.

As indicated under Test Results in 8.1, centrifugal hematology values cannot be obtained by the QBC method unless distinct cell layers with well-defined interfaces form in the blood tube. Non-separation or cell "streaming" can occur under certain hematologic or pathologic conditions, e.g., when an orange-yellow layer of granulocytes fails to form in the QBC tube, or when the lower boundary of granulocytes is so poorly defined that a clear interface cannot be identified. The condition is generally the result of a shift in red-cell specific gravity toward that of the granulocytic leukocytes, causing the red cells and granulocytes to intermingle.

Studies have shown that the frequency of unreadable QBC tubes is less than 1% among office patients of a general practitioner; among clinical outpatients and hospital patients the frequency of unreadable tubes may range from 1.5% to 10% depending on the pathologies of their patient populations.⁸

8.4 EXPECTED VALUES

The means and ranges listed in Table VIII-1 were determined by the QBC method from specimens taken from ambulatory adult donors working in an industrial environment. Table VIII-2 lists normal hematology ranges reported in the literature.

TABLE VIII-1
EXPECTED VALUES - QBC II PLUS HEMATOLOGY PARAMETERS⁸

Parameter		VENOUS BLOOD		CAPILLARY BLOOD	
		Mean Value ($\bar{x}$)	Range (± 2 S.D.)	Mean Value ($\bar{x}$)	Range (± 2 S.D.)
HCT (%)	Males	44.2	36.8-51.5	43.3	35.4-51.2
	Females	40.4	34.2-46.5	40.7	34.7-46.6
PLT ($\times 10^9/L$)		268	151-385	261	124-399
WBC ($\times 10^9/L$)		7.0	4.1-9.9	7.3	3.7-10.9
GRAN (%)		61.6	44.6-78.5	64.8	50.6-79.1
GRAN ($\times 10^9/L$)		4.5	1.8-7.2	4.5	2.2-6.9
LYMPH/MONO (%)		38.4	21.5-55.4	35.1	20.9-49.4
LYMPH/MONO ($\times 10^9/L$)		2.7	1.5-3.9	2.4	1.2-3.5

TABLE VIII-2
NORMAL HEMATOLOGY RANGES

HCT (%) ¹	Males	40.0-54.0
	Females	37.0-47.0
PLT ($\times 10^9/L$) ¹		140-440
WBC ($\times 10^9/L$) ¹		4.3-10.0
GRAN*	%	44.2-80.2
	($\times 10^9/L$)	2.0- 8.8
LYMPH/ MONO*	%	28.0-48.0
	($\times 10^9/L$)	1.2- 5.3

*Note: The normal ranges in Table VIII-2 for Granulocytes and Lymphocytes/Monocytes were derived from Miale¹². The reported normals for each white-cell type are grouped as Granulocyte and Lymphocyte/Monocyte sub-populations.

The Hemoglobin range in blood samples from normal adults tested by the QBC II Plus method is virtually identical to the following ranges reported in the literature¹:

- Males: 14-18 g/dL
- Females: 12-16 g/dL

It is recommended that each laboratory develop normal ranges based on the characteristics of its own patient population.

8.5 SPECIFIC PERFORMANCE CHARACTERISTICS⁸

8.5.1 Precision

Data on within-run reproducibility of QBC II Plus with Venous Tubes and Capillary Tubes at three blood levels are shown in Table VIII-3. The means and ranges listed are based on replicate tests performed on 10 tubes per sample, e.g., 70 tubes where "n=7". The precision studies were conducted over a period of months using several calibrated QBC Readers.

TABLE VIII-3
QBC II PLUS WITHIN-RUN PRECISION

Parameter	QBC Venous Blood Tubes			QBC Capillary Blood Tubes		
	No. of Samples (n=)	Mean Value	Mean C.V. (%)	No. of Samples (n=)	Mean Value	Mean C.V. (%)
HCT (%)	7	31.3	1.34	6	34.6	2.06
	16	40.9	1.38	16	40.6	2.29
	3	47.4	1.01	2	45.1	2.07
HB (g/dL)	1	10.9	0.8	1	4.9	3.0
	1	14.0	1.0	1	11.5	1.3
	1	16.4	1.4	1	17.9	0.9
PLT ($\times 10^9/L$)	13	128	10.90	12	136	15.48
	7	255	9.48	9	262	11.67
	6	430	7.30	3	336	6.96
WBC ($\times 10^9/L$)	3	4.57	4.43	3	4.6	9.07
	15	6.9	5.37	17	6.6	8.25
	8	11.93	4.33	4	12.8	4.96
GRAN (%)*	9	53.0	4.94	5	54.4	8.18
	18	64.6	3.47	11	64.2	6.46
	31	76.3	2.90	8	72.9	5.28
GRAN ($\times 10^9/L$)	8	2.26	8.35	4	2.4	8.5
	22	4.04	5.90	12	3.5	7.4
	28	7.16	4.90	8	6.8	5.2
LYMPH/MONO ($\times 10^9/L$)	15	1.42	12.60	9	1.7	15.3
	33	2.29	11.50	9	2.2	14.9
	10	3.27	7.90	6	2.9	11.2

*QBC % Granulocytes and % Lymphocytes/Monocytes always total 100%. Therefore standard deviations for % Granulocytes and % Lymphocytes/Monocytes are identical.

8.5.2 Accuracy

Data on the correlation of QBC II Plus Hematocrit, Hemoglobin, WBC and Platelet parameters with standard reference methods are tabulated in Table VIII-4 and Figures 8.3-8.10. For correlation data on Granulocyte and Lymphocyte/Monocyte counts, see Figures 8.11-8.18.

TABLE VIII-4
QBC II PLUS CORRELATION DATA (HCT, HB, WBC, PLT)

Parameter	Specimen (Reference Method)	n=	Range of Reference Values	Correlation Coefficient	Slope	Intercept
HCT (%)	Venous (Microhematocrit) ¹¹	200	16.5 - 56.6	0.9884	0.9952	-0.3655
	Capillary (Microhematocrit) ¹¹	100	34.0 - 50.7	0.9450	1.0000	0.0027
HB (g/dL)	Venous (Cyanmethemoglobin) ¹⁴	206	7.0 - 17.8	0.9905	1.0007	-0.0477
	Capillary (Cyanmethemoglobin) ¹⁴	112	10.1 - 18.2	0.9590	0.9888	-0.0507
PLT ($\times 10^9/L$)	Venous (See Note 1)	492	9 - 733	0.9056	0.9744	-8.2440
	Venous (Phase Microscopy)	101	2 - 869	0.9326	1.0260	-0.0583
	Capillary (UF-100)	99	146 - 383	0.7129	0.9903	0.1430
WBC ($\times 10^9/L$)	Venous (See Note 2)	385	1.8 - 32.0	0.9825	0.9613	0.5059
	Capillary (Coulter ZBI)	100	3.9 - 12.7	0.8652	0.9870	-0.0592

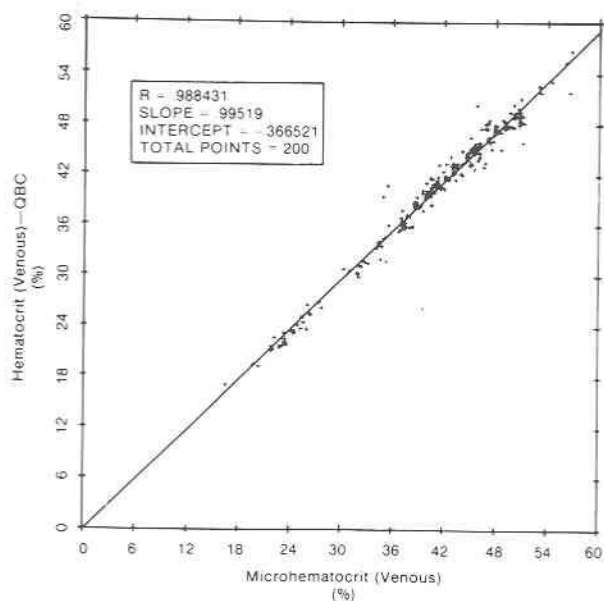


Figure 8.3.
Venous Blood Hematocrit:
QBC II Plus Correlation with Micro-
Hematocrit Reference Method.¹¹

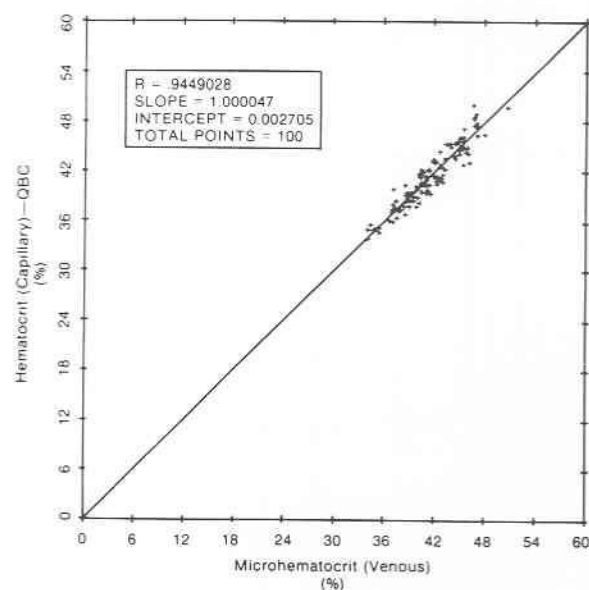


Figure 8.4.
Capillary Blood Hematocrit:
QBC II Plus Correlation with Micro-
Hematocrit Reference Method.¹¹

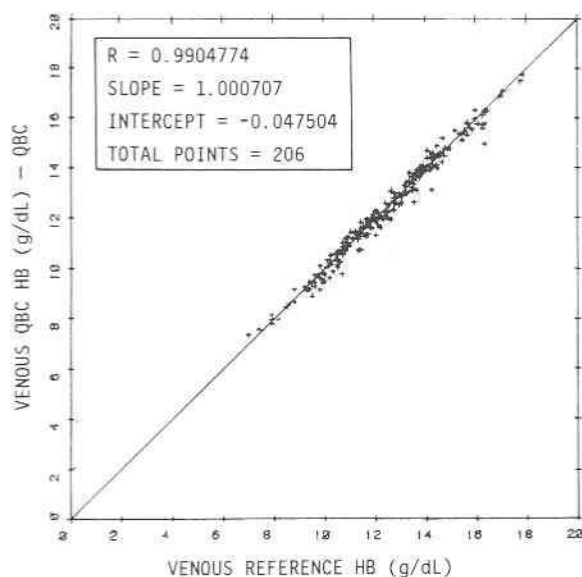


Figure 8.5.
Venous Blood Hemoglobin:
QBC II Plus Correlation with
Reference Hemoglobin¹⁴

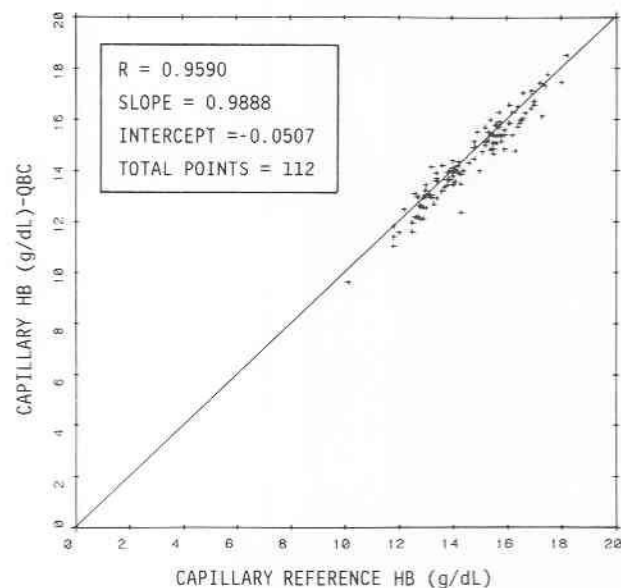


Figure 8.6.
Capillary Blood Hemoglobin:
QBC II Plus Correlation with
Reference Hemoglobin¹⁴

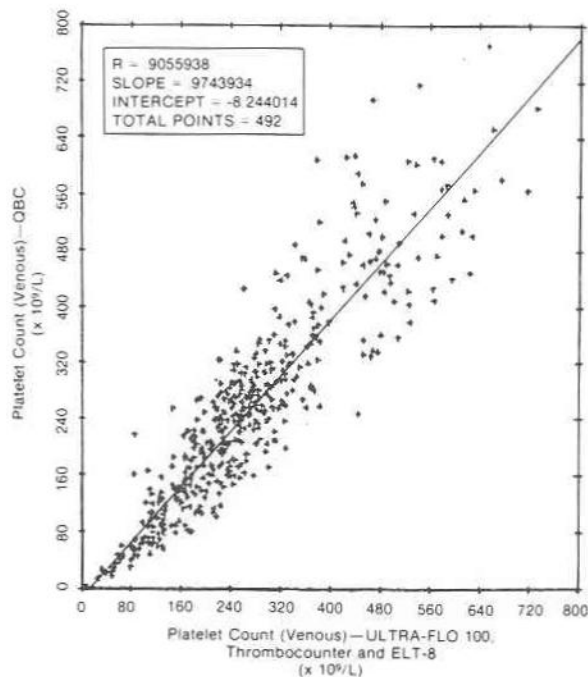


Figure 8.7.
Venous Blood Platelet Count:
QBC II Plus Correlation with ULTRA-FLO
100 and Coulter S+ Platelet Count.

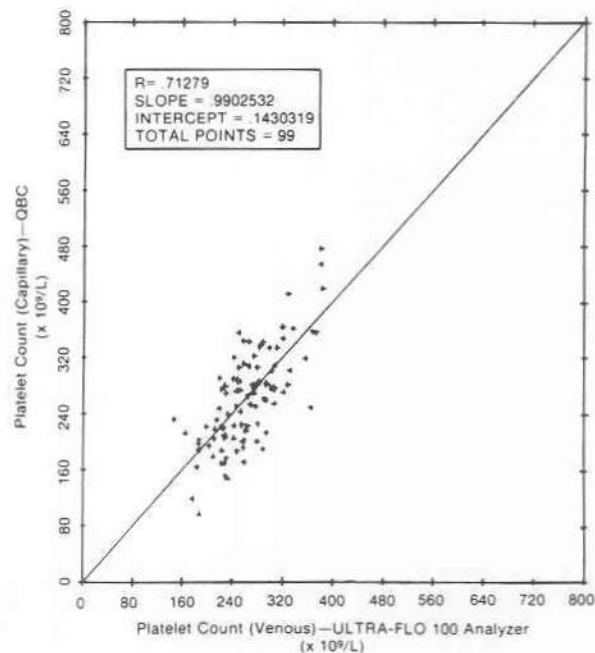


Figure 8.8.
Capillary Blood Platelet Count:
QBC II Plus Correlation with ULTRA-FLO
100 Platelet Count.

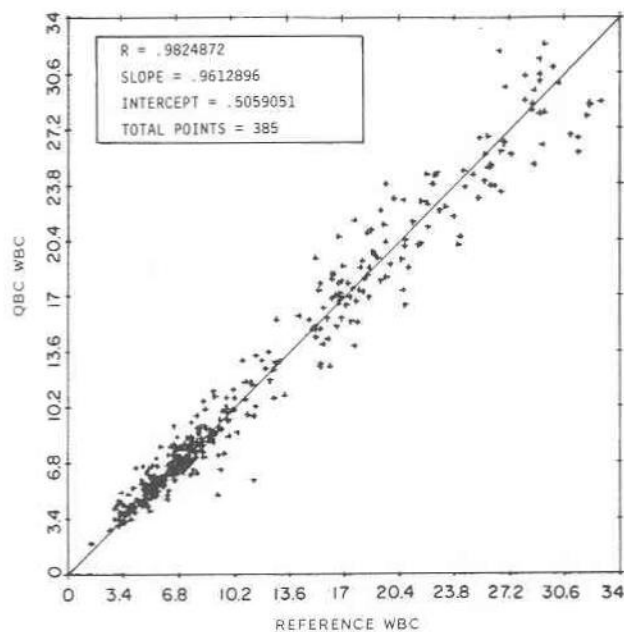


Figure 8.9.
Venous Blood White Cell Count:
QBC II Plus Correlation with Coulter
ZBI and Coulter S+ White Cell Count.

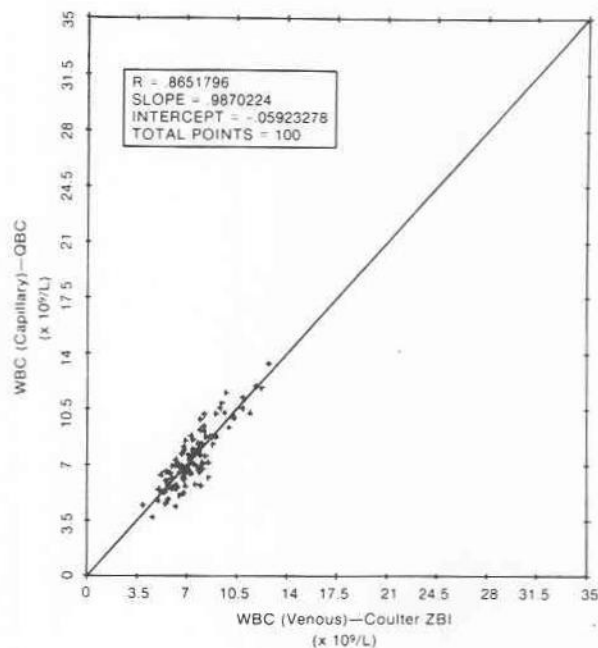


Figure 8.10.
Capillary Blood White Cell Count:
QBC II Plus Correlation with Coulter
ZBI White Cell Count.

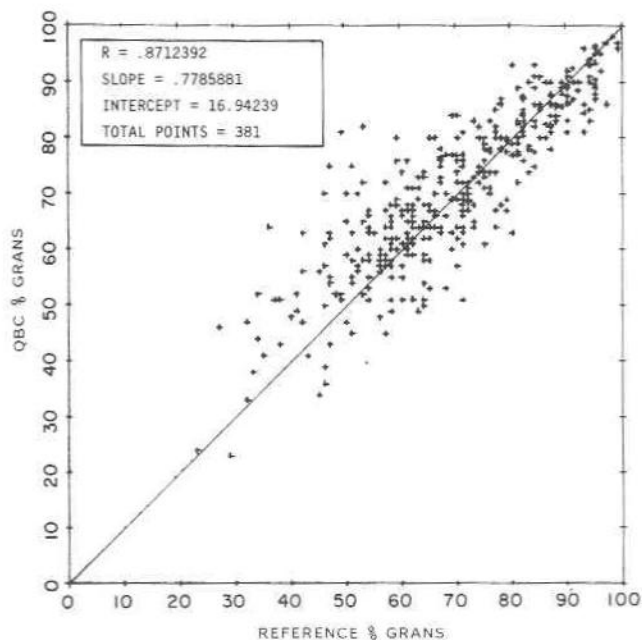


Figure 8.11.
Venous Blood % Granulocytes:
QBC II Plus Correlation with
100-Cell Manual Differential.

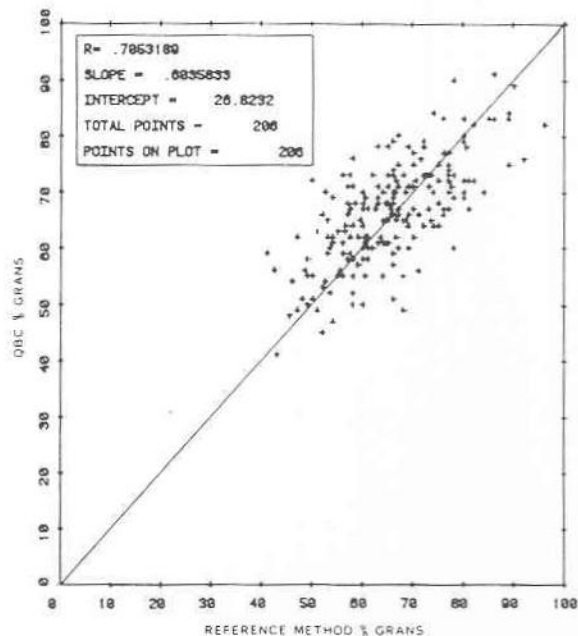


Figure 8.12.
Capillary Blood % Granulocytes:
QBC II Plus Correlation with
100-Cell Manual Differential.

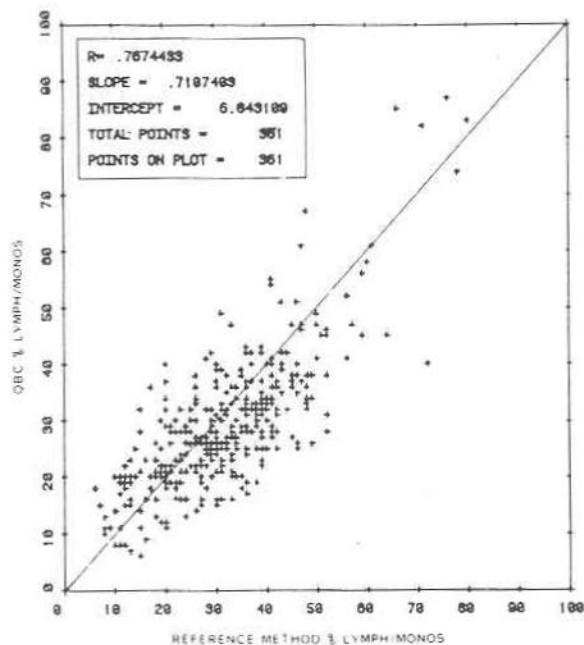


Figure 8.13.
Venous Blood % Lymph/Mono:
QBC II Plus Correlation with
100-Cell Manual Differential.

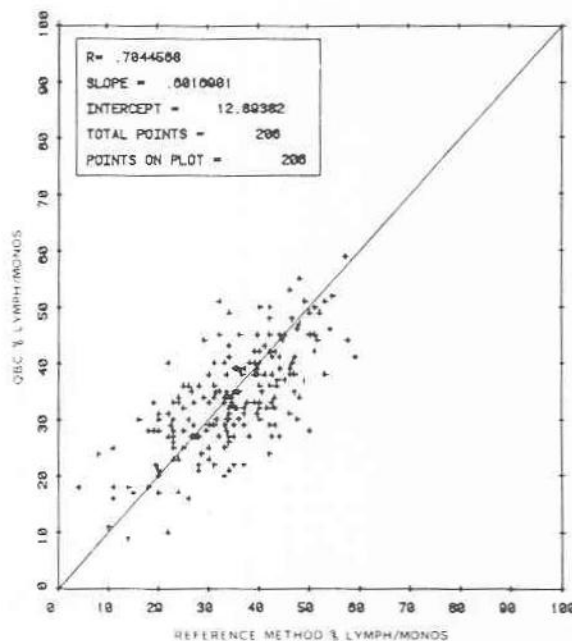


Figure 8.14.
Capillary Blood % Lymph/Mono:
QBC II Plus Correlation with
100-Cell Manual Differential.

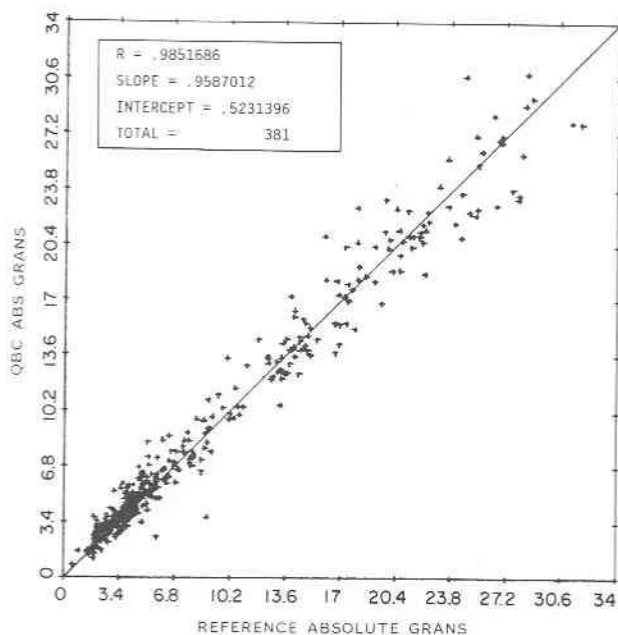


Figure 8.15.
Venous Blood Granulocyte Count:
QBC II Plus Correlation with
Reference Manual Count.

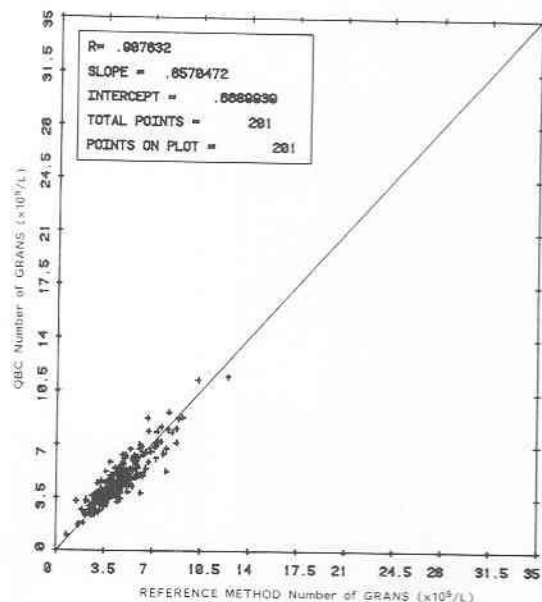


Figure 8.16.
Capillary Blood Granulocyte Count:
QBC II Plus Correlation with
Reference Manual Count.

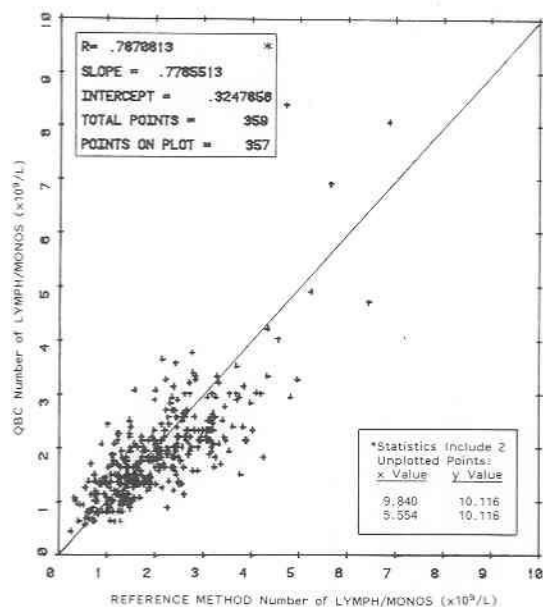


Figure 8.17.
Venous Blood Lymphocyte/Monocyte
Count: QBC II Plus Correlation
Reference Manual Count.

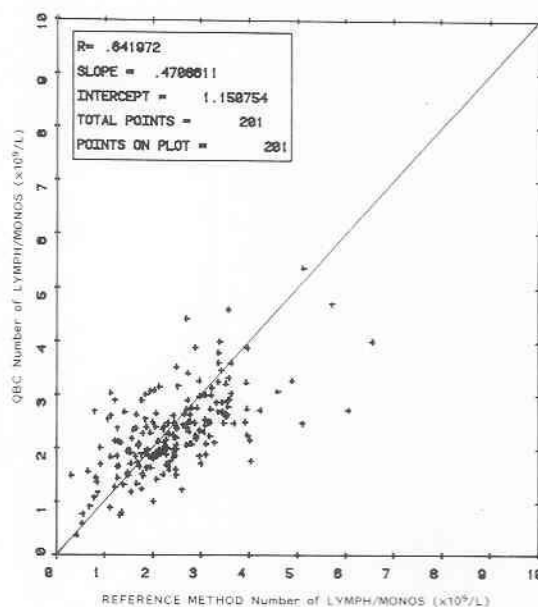


Figure 8.18.
Capillary Blood Lymphocyte/Monocyte
Count: QBC II Plus Correlation
with Reference Manual Count.

Section 9
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Appendix A
DISCUSSION OF ALERT FLAGS

Table IV-1 in Section 4 lists the alert flags and test result symbols that are programmed into the QBC II Plus Reader, together with brief summaries on probable causes of the flagged conditions. This Appendix provides more detailed descriptions on the test conditions most likely to trigger the flags and symbols.

"-L": Occurs when any interface reading yields a negative or a zero length, e.g., reading the 2nd interface after reading the 3rd interface, or reading the same interface twice.

"H2":* Can appear only after reading the 2nd interface in either the Venous or Capillary modes. For the flag to occur, the cone of the float would be virtually resting on the top of the closure. This condition could arise if: 1) the blood specimen is excessively plasma-rich (Venous Test only), i.e., the tube was filled with unmixed, sedimented blood; 2) the density of the float is too great (out of tolerance); or 3) the tube contains insufficient specimen due to a filling error or blood loss. In all cases, a new tube must be prepared and the test repeated. If the specimen is venous blood, be sure it is well mixed. Reappearance of the flag would suggest an extremely low hematocrit.

"H1":* Can appear only after reading the 3rd interface in either the Venous or Capillary modes. This condition could result from: 1) a defective (out of tolerance) float, causing the light-red erythrocyte layer to extend above the float; or 2) an extremely high hematocrit or other blood abnormality, causing the same condition. The test should be repeated with a new tube and float to eliminate the possibility of a defective float. Reappearance of the "H1" flag indicates that the specimen must be tested by other methods.

"L2":* Can appear after either the 4th, 5th or 6th interface reading in the VENOUS MODE ONLY. It occurs when the top of the cell layer extends above the top of the float. When an "L2" appears after entering the 4th or 5th interface, a valid hematocrit (HCT) test value will be displayed; when it occurs after entering the 6th interface, valid HCT, WBC, GRANS and LYMPH/MONO values will be displayed.

The "L2" flag usually indicates an abnormally large population of white cells or platelets.

"A8":* Can appear ONLY IN THE CAPILLARY MODE. Can occur: 1) if the top of float is read instead of the meniscus; 2) if the Capillary Tube was either grossly over-filled or contains insufficient blood due to a filling error or blood loss; or 3) with a high white cell count, platelet count or blood abnormality, causing a cell layer to extend beyond the top of the float. If another capillary specimen can be obtained, the test should be repeated with a correctly filled tube. Reappearance of the "A8" flag indicates that the specimen must be tested by other methods.

*Always prevents display of hemoglobin value.

Over-
range
and no
value
Flags:

The flashing flags "---" for HCT, "99.9" for WBC, and "999" for Platelets appear when the test value exceeds the dynamic capability or display limits of the Reader. In such cases, the specimen must be tested by other methods to determine the flagged parameter.

The "---" flag with no test value will appear in HB in the following cases: if any other test value is flagged; HCT used in the derivation of HB is below 15 % or above 65 %; or the computed HB is below 5 g/dL or above 20 g/dL.

The displayed HB test result will flash on and off whenever the red cell density factor, which was used in the derivation of hemoglobin, is outside pre-programmed limits. In such cases, the blood specimen should be examined more closely, preferably by a peripheral smear, to determine the nature of the abnormality.

"P1"/
"P2"
(Ser-
vice
Flag):

Appearance of a flashing Service Flag "P1" or "P2" in the platelet (PLT) display immediately after pressing the POWER or CLEAR button indicates a transient condition or malfunction in the random access memory (RAM) or read only memory (ROM) of the microprocessor. If a Service Flag cannot be cleared by pressing the Power switch off and on, Request Service.

Appendix B TEST PRINTOUTS

As noted previously, the QBC II Plus Reader incorporates circuitry and a communications port for operation with an Epson LX-series printer. Instructions for connection to a printer are described in Section 2.2.3.

• Obtaining Test Printouts

Detailed instructions for operating the Epson Printer are provided in the manufacturer's handbook supplied with the Printer.

When the Reader-to-Printer system is functional, transmission of test results to the printer is initiated within microseconds after pressing "ENTER" at the last interface of the QBC blood tube, i.e., 6th in the "VEN" mode and 7th in the "CAP" mode. Test results will be displayed on the panel of the Reader while data transmission to the printer is in progress.

• Format and Flags:

Test results are printed on perforated, adhesive-backed 3" x 4" labels supplied in the Catalog 4482 Printer Kit. As shown in Figure B-1, the type of QBC test (i.e., Venous Sample or Capillary Sample) is printed on the label, with space provided for writing in the patient's name and the test date.

QBC CENTRIFUGAL HEMATOLOGY SYSTEM		
Patient	_____	
Date	_____	
Venous Sample		
PLT	=225	x10 ⁹ /L
HCT	=33.1	%
HGB	=11.5	g/dL
WBC	=10.4	x10 ⁹ /L
# GRANS	=5.0	x10 ⁹ /L
# LYMPH	=5.4	x10 ⁹ /L
% GRANS	=48	%WBC
% LYMPH	=52	%WBC

Figure B-1. Printout Format of Typical QBC Venous Blood Test.

QBC CENTRIFUGAL HEMATOLOGY SYSTEM		
Patient	_____	
Date	_____	
Venous Sample		
PLT	=L2**	x10 ⁹ /L
HCT	=34.1	%
HGB	=--.-**	g/dL
WBC	=16.5	x10 ⁹ /L
# GRANS	=9.6	x10 ⁹ /L
# LYMPH	=6.9	x10 ⁹ /L
% GRANS	=58	%WBC
% LYMPH	=42	%WBC

Figure B-2. Sample Printout Showing Error Flag for PLT Parameter.

In an error condition, the Reader will transmit and print an alphanumeric "alert flag" with two asterisks (**) opposite the appropriate parameter and dashes opposite hemoglobin (HB). See the example in Figure B-2. Upon completion of the transmission, the same alert flag will flash on the display panel of the Reader.

As discussed under Alert Flags in Section 4.3.5, further testing depends on the nature of the problem that caused the error condition and will generally involve:

- Repeating the test with the same QBC blood tube;
 - Re-testing with a newly prepared QBC blood tube; or
 - Obtaining only partial test results (or no results) due to anomalies in the blood that may render the tube unreadable.
- Troubleshooting

If test results are displayed on the QBC II Plus Reader, but are not recorded by the printer, check and correct the following:

- a) Printer "Power" switch is OFF.
- b) Printer "On Line" light and switch are OFF.
- c) "No Paper" light of printer is on, indicating unit is out of label roll stock.
- d) Interface cable at printer or Reader is loose or disconnected.

If problems with the printing function persist, request technical service for correction of a circuit malfunction.

Appendix C
PARTS LIST -
QBC II PLUS DISPOSABLES, ACCESSORIES, AND SPARES

Reorder No.

TEST DISPOSABLES

QBC Venous-Blood Tubes (100 tests)	4240
QBC Capillary-Blood Tubes (100 tests)	4241

REPLACEMENT ACCESSORIES

Work Station	4226
QBC Venous-Blood Pipetter (with spare O-rings and grease)	4225
O-rings, Pipetter (set of 3)	4225-603-000
Grease, Pipetter (1 box)	2513-611-000
QBC II/QBC II Plus Venous Cal Check Tube	4235
QBC II/QBC II Plus Capillary Cal Check Tube	4236
Operator's Manual	4247
Forceps	4227-610-000
Spare Parts & Accessories Kit	4239
Dust Cover	4527

SPARE PARTS

Lamp, Reticle Arrow - 1 ea.	2510-624-513
Lamp, Tube (White) Light - 1 ea.	2510-624-512
Lamp, Illuminator - 1 ea.	4227-602-000
Thrust Pivot, Tube Holder	4460-602-001
Digit Display, Seven Segment Readout	2510-621-746
Fuse, 3AG 1-1/2 Amp. - 5 ea.	2510-623-814
Grease, Lead Screw (1 tube)	4200-600-006
POWER Switch (120 volt)	4460-650-002

PRINTER SYSTEM

QBC Printer Package	4482
Reader-to-Printer Ribbon Cable	4407
Data Printing Labels (2500 ea.)	2303

REFERENCE CONTROLS

QBC Hematology Controls, 2 Vials ea., Normal and Abnormal	4242
---	------

Appendix D
WARRANTY - QBC II PLUS SYSTEM

Becton Dickinson Primary Care Diagnostics, (hereinafter referred to as Becton Dickinson), warrants the QBC II Plus System to be free from defects in workmanship and materials for a period of one (1) year from date of installation, provided the system is operated in accordance with the QBC II Plus System Operator's Manual. During such period, Becton Dickinson agrees to replace or repair any parts which, in its judgment, are found to be defective, provided the system has not been subjected to misuse or abuse. The warranty stated herein shall extend to the original consumer and not to any subsequent consumer of the System.

Becton Dickinson shall not be liable for any incidental or consequential damages. Becton Dickinson makes no other warranties, expressed or implied, except as stated herein.

QBC II Plus OPERATOR'S MANUAL
Catalog/Reorder No. 4247

BECTON
DICKINSON

Becton Dickinson
Primary Care Diagnostics
One Becton Drive
Franklin Lakes, N.J. 07417-1882

QBC®
Centrifugal
Hematology Analyzer

MAINTENANCE MANUAL
for the



Model 4207

Becton Dickinson
Primary Care Diagnostics

One Becton Drive, Franklin Lakes, New Jersey, U.S.A. 07417

BECTON
DICKINSON

Manual No. 4207-502-000

Original Issue May 1990

MAINTENANCE MANUAL
for the



Centrifuge

Model 4207

Becton Dickinson
Primary Care Diagnostics

One Becton Drive, Franklin Lakes, New Jersey, U.S.A. 07417

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DICKINSON

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SECTION 1. GENERAL INFORMATION

1.1 SCOPE OF MANUAL

This maintenance manual provides service information and procedures for QBC Centrifuge Model 4207 (Figure 1-1), which is manufactured by Becton Dickinson Primary Care Diagnostics.

1.2 PURPOSE OF EQUIPMENT

The QBC Centrifuge is a high-speed laboratory instrument that produces packed cell volumes for the quantitative measurement of hematologic values by the QBC method.

The centrifuge is a tube-preparation accessory to the QBC Centrifugal Hematology Analyzer System (Catalog No. 4465). Special-purpose QBC blood tubes can be accommodated, which, under centrifugation, differentiate and expand the cell layers of the buffy coat. The tubes, when measured on a QBC_{II} Reader, yield a hematocrit, as well as the platelet count, total white-cell count, and counts of the granulocyte and lymphocyte/monocyte subpopulations.

1.3 EQUIPMENT SUPPLIED

The equipment supplied is QBC Centrifuge Model 4207. Step-Down Transformer Model 4477-505-000 is supplied, where applicable, to reduce a 220-240 V, 50/60 Hz main to the 120 V required at the centrifuge.

1.4 EQUIPMENT REQUIRED BUT NOT SUPPLIED

A QBC_{II} Reader Model 4477, venous blood pipetter, a workstation, and associated test accessories are required for the centrifuge to function as a preparation accessory to the QBC Centrifugal Hematology Analyzer.

1.5 TECHNICAL CHARACTERISTICS

Technical characteristics of the centrifuge are provided in Table 1-1.

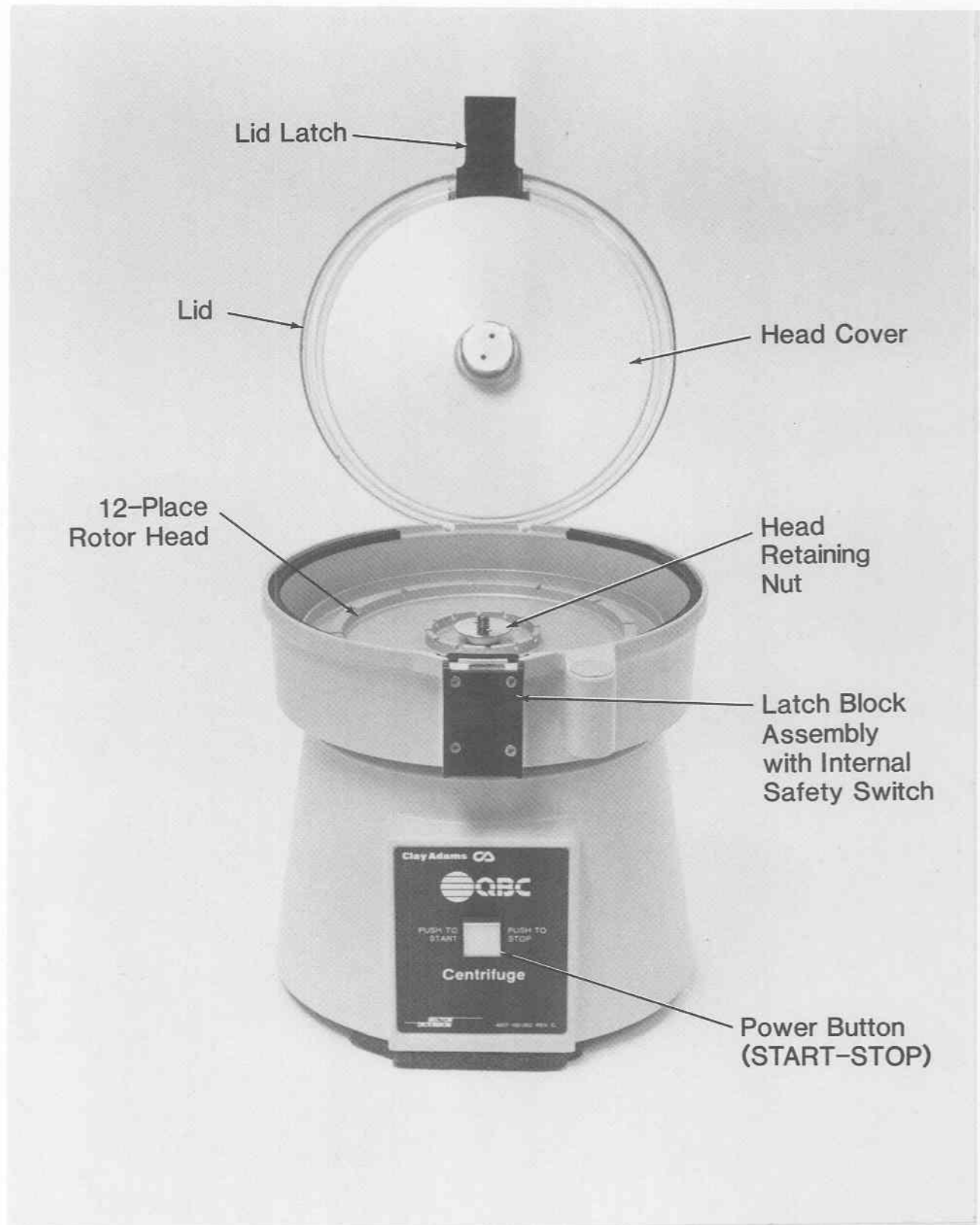


Figure 1-1. QBC Centrifuge Model 4207

TABLE 1-1. TECHNICAL CHARACTERISTICS OF CENTRIFUGE

<u>Characteristic</u>	<u>Description</u>
Rotor capacity	12 QBC blood tubes
Speed @rated voltage	Approx. 12,000 RPM.
Relative centrifugal force @rated voltage	Approx. 14,387 x g.
Timer	Electronic, fixed 5-minute cycle.
Safety interlock switch	Actuated by lid latch. Centrifuge motor is inoperable unless interlock switch is actuated (lid fully closed and latched).
Motor brake	Electric, actuated automatically by timer after completion of spin cycle. Actuated manually by pressing PUSH TO START/PUSH TO STOP switch.
Power Requirements:	
Without step-down transformer	120 V $\pm 10\%$, 50/60 Hz, 4 amp max (avg. 180 W), typical current 1.4A, single phase.
With step-down transformer	230 V $\pm 10\%$, 50/60 Hz, 2.3 amp max (avg. 190 W), typical current 0.9A, single phase.
Fuse, on timer circuit board	4 amp Slo-Blo (3AG)
Power cord	Two flat blades with ground pin, 2.0 m (6.5 ft) long.

1.6 PHYSICAL CHARACTERISTICS

The dimensions and weight of the centrifuge and step-down transformer, both packed and unpacked, are given in Table 1-2. The centrifuge with lid assembly raised is 42.7 cm (16.8 in.) high.

TABLE 1-2. PHYSICAL CHARACTERISTICS

<u>Characteristic</u>	<u>Weight (kg/lb)</u>	<u>Volume (m³/ft³)</u>	<u>Height (cm/in.)</u>	<u>Width (cm/in.)</u>	<u>Depth (cm/in.)</u>
CENTRIFUGE:					
Packed	7.5/16.5	0.04/1.4	39.9/15.7	31.7/12.5	31.7/12.5
Unpacked	5.4/12		22/8.7	21.6/8.5	25.4/10
TRANSFORMER:					
Packed	2.3/5.1	0.02/0.06	9.3/3.6	20.5/8.1	9/3.5
Unpacked	2.2/4.75		9/3.5	7.5/2.95	11.7/4.6

1.7 ENVIRONMENTAL REQUIREMENTS

The environmental requirements of the centrifuge are given in Table 1-3.

TABLE 1-3. ENVIRONMENTAL REQUIREMENTS

<u>Characteristic</u>	<u>Operating Limits</u>	<u>Storage Limits</u>
Temperature	20° to 32°C (68° to 90°F)	-26° to 55°C (-15° to 131°F)
Relative Humidity (Non-condensing)	10% to 95%	10% to 95%

1.8 ELECTROSTATIC DISCHARGE (ESD)

The QBC Centrifuge contains a printed-circuit board on which are installed metal-oxide-semiconductor (MOS) devices. The MOS devices are subject to damage from electrostatic discharge.

Electrostatic discharge can occur at any time, but the probability of it occurring is increased when the humidity is low. The exercise of some simple precautions will minimize the likelihood of damage by ESD:

- Before handling the timer circuit board, touch a metal object, such as the centrifuge housing, to discharge electrostatic buildup from your body.

- Avoid touching, when possible, the MOS devices or their contacts.
- Stand on an anti-electrostatic mat to work on the timer circuit board. Use an anti-static work surface.
- If the timer circuit board is removed and is to be shipped, e.g., back to the factory, first place the printed-circuit board in an anti-electrostatic bag.

SECTION 2. INSTALLATION

2.1 UNPACKING

Examine the outer shipping container carefully to see if it has been damaged, e.g., punctured, dented at the corners, etc. Open the carton immediately if it is damaged, and inspect the equipment thoroughly for damage, such as dents or scratches. Notify the carrier if the equipment is damaged, and request a Damaged Equipment Report form.

The method of unpacking is shown by the exploded-view drawing in Figure 2-1. Unpack each carton as it is removed, and check its contents against the packing list, Table 2-1. Store the packing materials for possible future reuse.

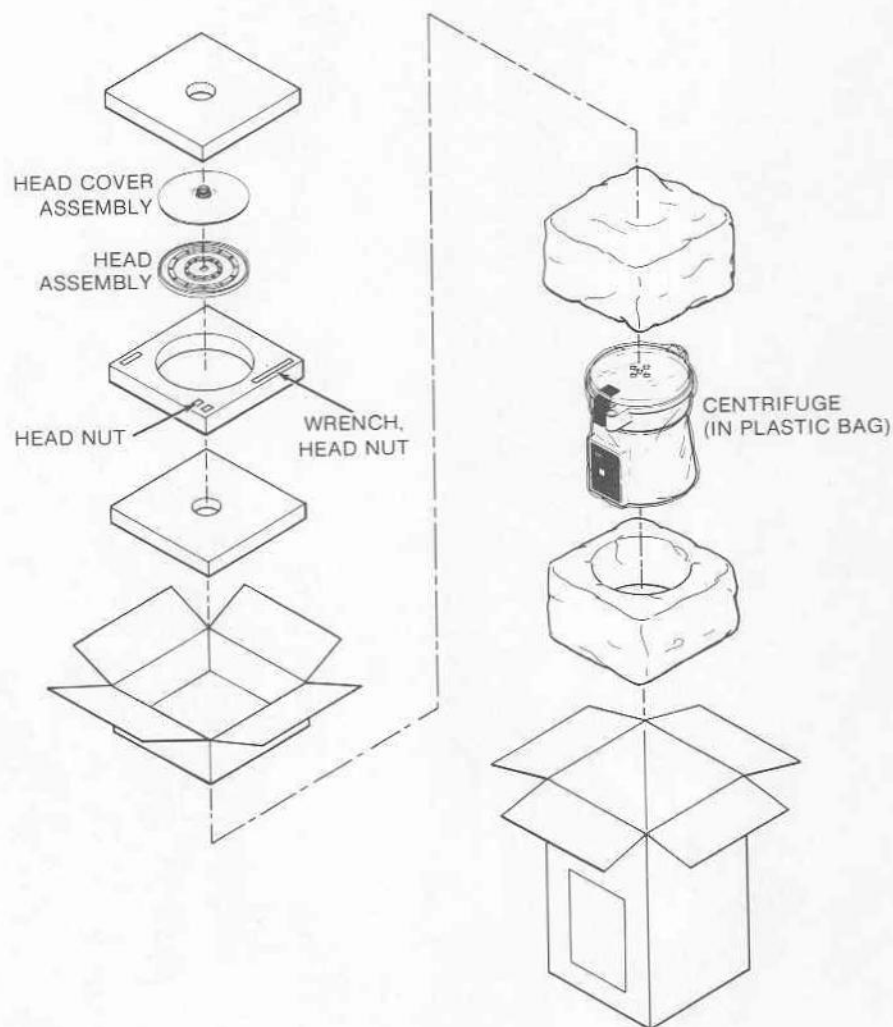


Figure 2-1. Unpacking Diagram

TABLE 2-1. PACKING LIST

<u>Item</u>	<u>Quantity</u>
Centrifuge Shipping Carton, contains:	
Carton Assembly, Head:	
Cover Assembly, Head	1
Head Assembly	1
Head Nut	1
Wrench, Head Nut	1
Centrifuge Assembly	1

2.2 ASSEMBLY PROCEDURE

The unassembled rotor head and rotor cover are boxed separately from the rest of the centrifuge inside the centrifuge shipping container. This separate box includes a flanged head nut and a wrench for attaching the rotor head to the D-shaped motor shaft. Install the rotor head by referring to Figure 2-2 and performing the following procedure:

- a. Open lid of centrifuge.
- b. Remove tape from motor shaft adapter.
- c. Place D-shaped hole of rotor onto threaded D-shaped rotor shaft. Ensure that rotor is fully bottomed on motor shaft and motor shaft adapter.
- d. Thread head nut onto motor shaft, flanged side up.
- e. Place pins on head nut wrench into holes of head nut; holding rotor head with one hand, turn wrench clockwise to tighten head nut.

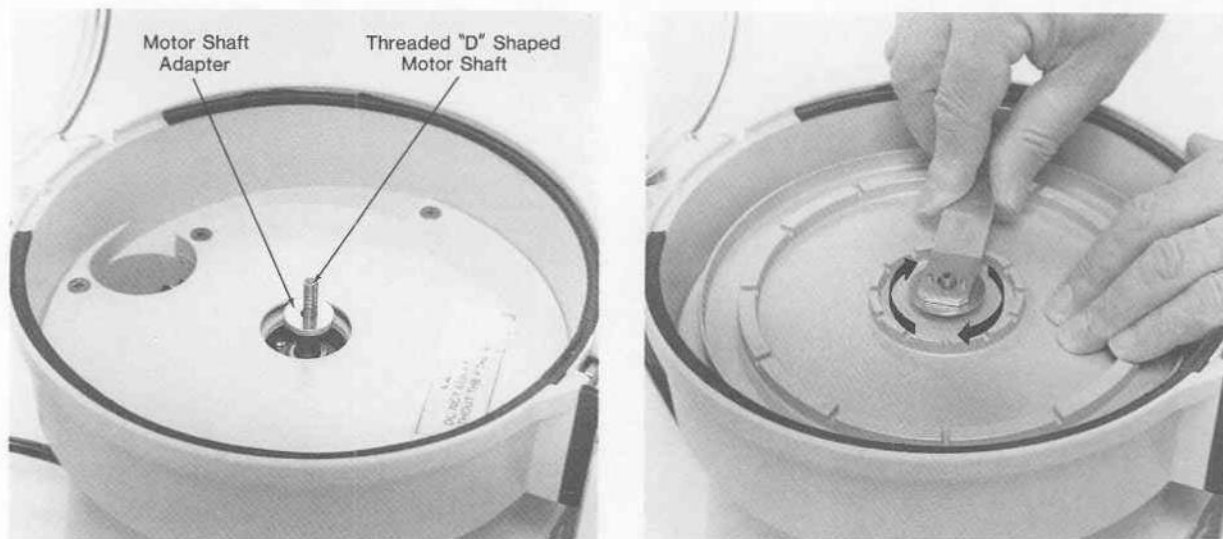


Figure 2-2. Head Assembly Details

2.3 CENTRIFUGE LOCATION REQUIREMENTS

Always place the QBC Centrifuge on a stable, level table or counter surface.

CAUTION

Locate the centrifuge where it will not be exposed to direct sunlight. Centrifugations in direct sunlight can elevate the rotor temperature and may cause adverse effects on the cell banding in QBC blood tubes.

2.4 INPUT POWER REQUIREMENTS

The input power requirements of the centrifuge are given in Table 1-1.

2.5 CABLE FABRICATION

There are no interconnecting cables between the centrifuge and other items of the system.

SECTION 3. OPERATION

The only operating control of the centrifuge is the white switch on the front panel labeled PUSH TO START/PUSH TO STOP (Figure 3-1). This switch is a push on/push off switch to control power on/off in the centrifuge.

3.1 STARTING

The centrifuge is started by pressing lightly on the white PUSH TO START/PUSH TO STOP switch on the front panel. The lens of the switch illuminates when the motor is powered. The centrifuge reaches rated speed within approximately 15 seconds. The interlock switch near the lid latch prevents the centrifuge from operating unless the latch is fully engaged.

CAUTION

Always ensure that the metal cover is installed before starting to centrifuge blood tubes. The head cover must be installed to prevent tube breakage and loss of samples.

3.2 OPERATING

3.2.1 LOADING AND BALANCING ROTOR HEAD

Blood tube positions on the rotor head are numbered counterclockwise from 1 through 12 for specimen identification. Each carrier-slot position has a number stamped next to it. Load the blood tubes as follows:

- a. Locate position 1 on rotor head.
- b. Insert open end of first blood tube under flange of head nut (Figure 3-2).
- c. Lower blood tube into position 1 tube slot.
- d. Position closure of blood tube snugly against outer rim of rotor head.



Figure 3-1. Location of PUSH TO START/PUSH TO STOP Switch

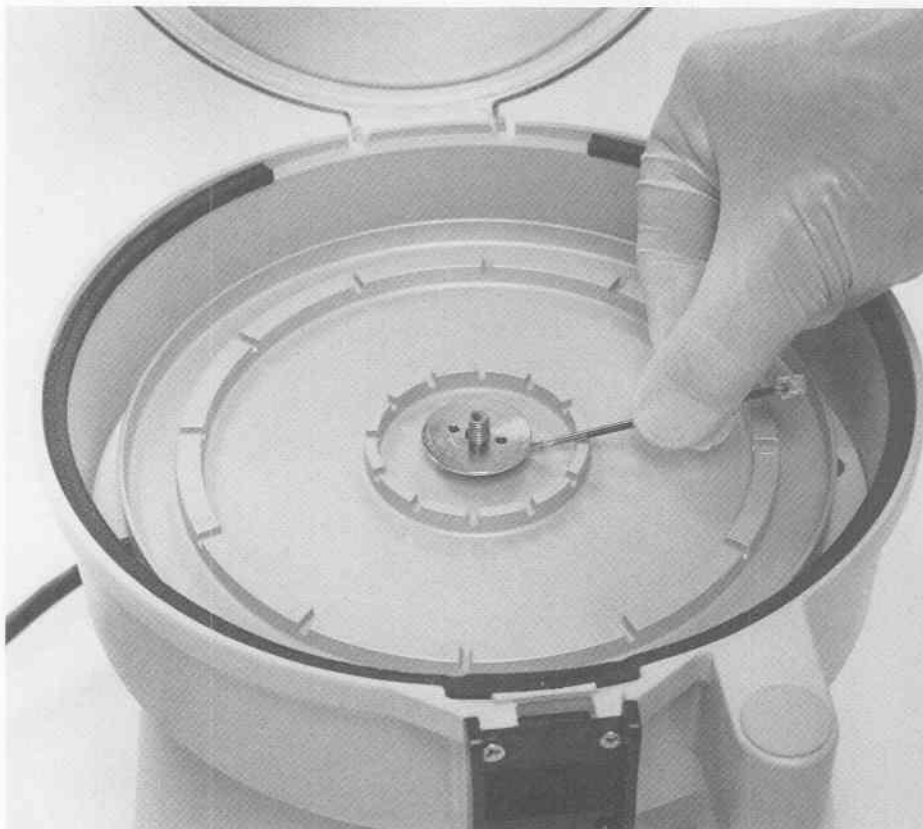


Figure 3-2. Placing QBC Blood Tubes on Rotor Head

- e. Repeat Steps a. through d. for remaining blood tubes, placing blood tubes on rotor head in a balanced array.

CAUTION

When spinning odd number of tubes, balance rotor head by placing empty QBC blood tube, fitted with closure and float, into carrier-slot position opposite odd tube. Maintain proper identification of test specimens when balancing tubes.

CAUTION

Ensure that closure of every QBC blood tube rests against outer rim of rotor head before installing head cover.

3.2.2 SECURING HEAD COVER AND LID

- a. Lower head cover onto threads of motor shaft.
- b. Turn knurled head cover knob (Figure 3-3) clockwise. Holding head cover with one hand, continue to turn head cover knob until head cover is tight on motor shaft.
- c. Close lid of centrifuge.
- d. Press down firmly until handle of lid latch (Figure 3-4) snaps into latch block on housing.

NOTE

Internal safety interlock switch will not actuate and centrifuge will not operate unless it is securely latched.

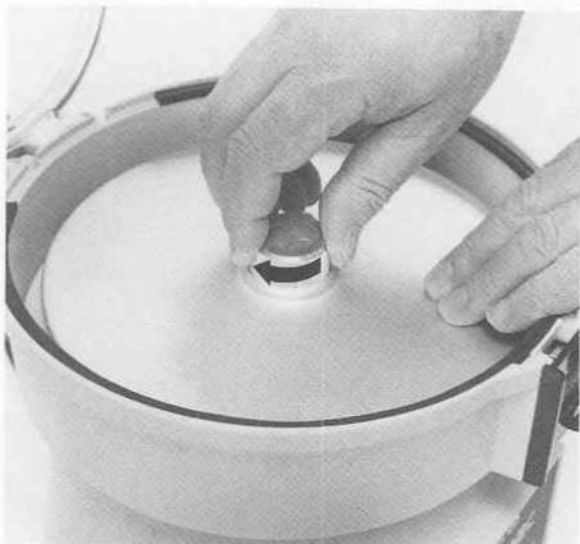


Figure 3-3. Installing Head Cover



Figure 3-4. Securing Lid Latch

3.3 STOPPING

When the 5-minute centrifugation period has elapsed, the lens of the PUSH TO START/PUSH TO STOP switch extinguishes and the electrically actuated brake causes the rotor head to decelerate. The rotor head stops within 30 to 35 seconds after the switch lens extinguishes.

NOTE

The centrifuge can be stopped at any time during the timed cycle by pressing the PUSH TO START/PUSH TO STOP switch once. The timer recycles to zero when the centrifuge is stopped before the end of the complete cycle.

SECTION 4. THEORY OF OPERATION

4.1 BLOCK DIAGRAM

The electrical circuits of the centrifuge are divided into five functional blocks. These functional blocks are designated M1 through M5 and are identified in Figure 4-1. Figure 4-1 also shows the waveforms to be expected at the identified test points.

4.2 CIRCUIT OPERATION

Refer to the block diagram, Figure 4-1 and to the schematic diagram, Figure 8-1.

4.2.1 POWER SUPPLY M1

The power supply develops a constant 12 VDC to operate the timer circuits. The power supply is controlled by a Zener diode, which clamps the output at +12 volts.

4.2.2 TRIGGER INPUT CIRCUIT M2

Pressing PUSH TO START/PUSH TO STOP switch S1 turns on centrifuge power and sends a short pulse (see test point TP2) to reset flip-flop U1 in timing latch M3. Closing S1 starts the 300-second (5-minute) timing cycle of the centrifuge by applying a trigger pulse to integrated circuits U1 and U2. The waveform at TP1 normally is 1.0 volt during the period of the timing cycle.

Opening the lid closes the contacts of the lid switch. Closure of the lid switch at any time during the timing cycle causes the voltage at TP1 to become 12 volts for as long as the lid switch is closed, interrupting that cycle and resetting the trigger input circuit. This sets the flip-flop in U1: Q-not goes to logic 0, Q1 turns off, and K1 is de-energized.

4.2.3 TIMING LATCH M3

The momentary closing of switch S1 clears flip-flop U1, causing 12-volt power to be applied to timer U2 for the period of one 300-second cycle. This power output from U1 can be measured at TP4. The clock pulses generated by U2, 9.15-ms $\pm$ 5% square waves, are available for measurement, but only during the timing cycle, at TP3.

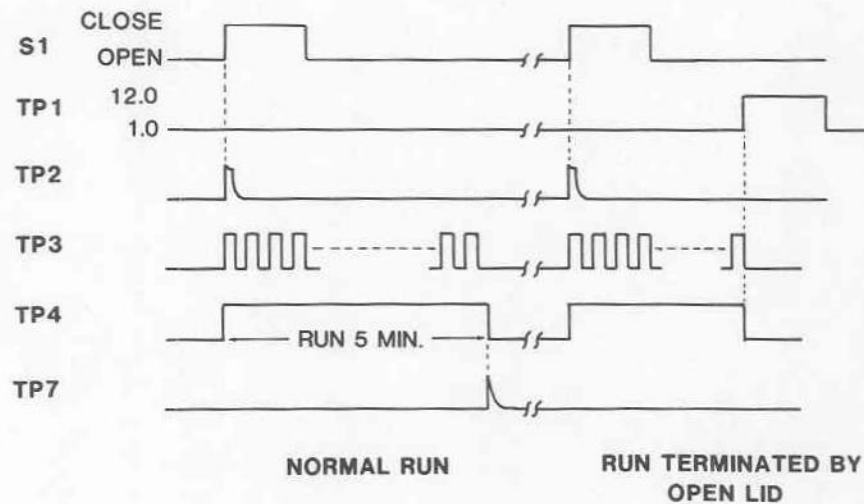
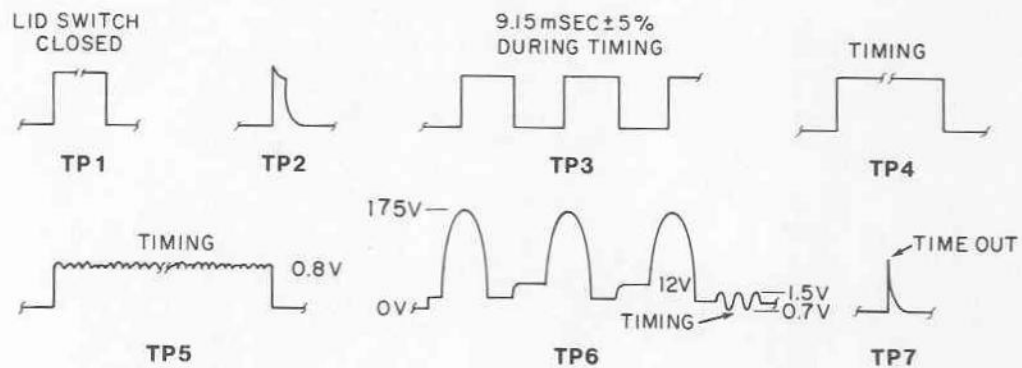
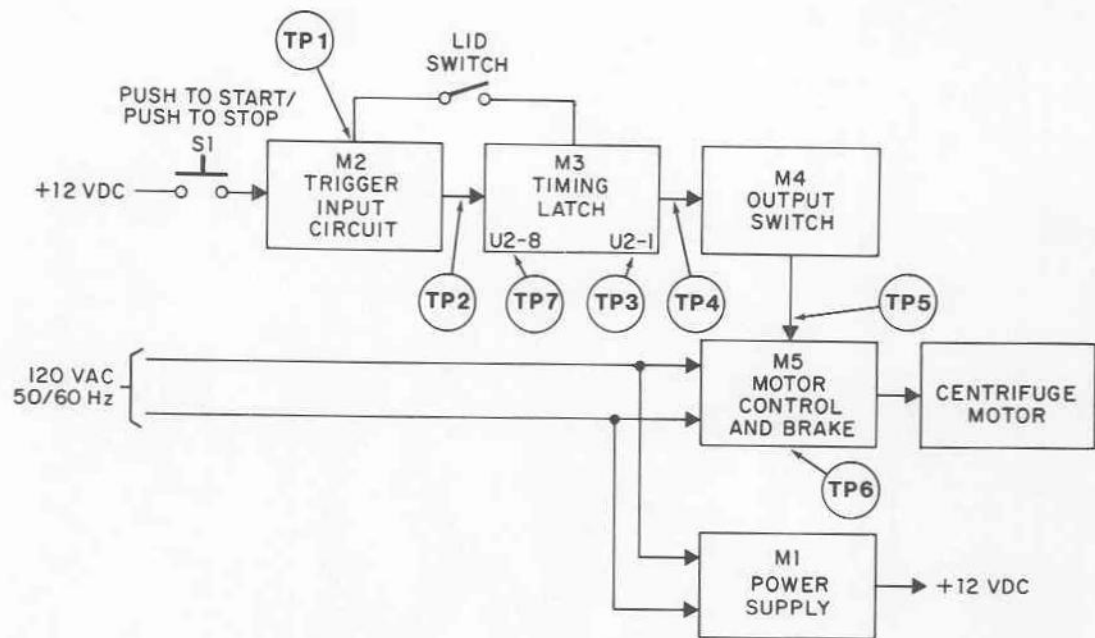


Figure 4-1. Simplified Block Diagram of Centrifuge

A time-out pulse (see TP7) is generated at pin 8 of U2 at the end of the timing cycle (after 300 seconds, or 5 minutes). This pulse triggers flip-flop U1. Triggering the flip-flop removes power from timer U2, terminating the timing cycle.

4.2.4 OUTPUT SWITCH M4

During the timing cycle, the 12-volt output from flip-flop U1 is applied across a resistive voltage divider in M4, causing 0.8 volt to be applied to the gate of silicon-controlled rectifier (SCR) Q1 (TP5). The 0.8-volt input at the gate of Q1 turns on Q1. The voltage at TP6 is the voltage across output switch M4: one-half of line voltage (half wave) during the timer off mode; or 1.5 volts AC during timer on mode. The drop from one-half of line voltage to 1.5 volts allows relay K1 to energize.

4.2.5 MOTOR CONTROL AND BRAKE M5

Energizing relay K1 causes its contacts to close, connecting the armature of the centrifuge motor to 120-volt, 50/60-Hz power and causing the motor to run. The motor is controlled, therefore, by energizing or deenergizing relay K1. The motor is protected against overspeed by its self-contained governor; when the motor speed approaches its maximum limit (13,100 RPM), the centrifugal force on the governor contacts cause the contacts to open, removing operating power from the motor until its speed again is within operating limits.

Arc suppressors on the timer circuit board protect the motor circuit during operation.

At the end of the 300-second period of timer U2 in timing latch M3, a time-out pulse at pin 8 of U2 sets flip-flop U1. Setting U1 removes the 0.8-volt input from the gate of SCR Q1 in output switch M4, turning off Q1. Turning off Q1 deenergizes relay K1 in motor control and brake M5. The contacts of K1 open, removing operating power from the motor, causing the motor to brake.

SECTION 5. MAINTENANCE

5.1 LIST OF TEST EQUIPMENT

The test equipment required, or equivalent, to maintain the QBC Centrifuge is listed in Table 5-1.

TABLE 5-1. TEST EQUIPMENT REQUIRED

<u>Equipment</u>	<u>Manufacturer</u>	<u>Use</u>
Multimeter AN/USM-303A	Western Reserve Electronics Model 300MA	General use for voltage and resistance checks
Oscilloscope OS-262(P)/U	Tektronix 7623A	Waveform measurements
Plug-in Unit, Dual Trace TD-1159/U	Tektronix 7B53	Extension of oscilloscope capabilities
Amplifier, Dual Trace AM-6785/U	Tektronix 7A26	Extension of oscilloscope capabilities
Adams Photoelectric Tachometer	Becton Dickinson 5205-000-000	Checking of centrifuge rotational speed
Stopwatch, 1-second accuracy	Any available	Checking of timer accuracy

5.2 SPECIAL TOOLS

A Head Nut Wrench, Becton Dickinson Part No. 4457-614-000, is required to maintain the QBC Centrifuge. This tool is provided in the shipping kit for each centrifuge.

5.3 PREVENTIVE MAINTENANCE

5.3.1 CLEANING

5.3.1.1 General Procedure

Use soap or a mild detergent and water to clean the lid, housing, and other parts of the centrifuge.

CAUTION

Do not use solvents or strong abrasives. They may scratch or damage surface on which they are used.

5.3.1.2 Head and Head Cover Cleaning Procedure

CAUTION

Always disassemble and remove the rotor head from the centrifuge for cleaning. The approved procedure for cleaning and disinfecting the rotor head requires the head to be immersed, rinsed, and dried.

The rotor head and cover are made of aluminum and can be damaged by chemicals and disinfecting agents.

Clean and disinfect the rotor head and cover as follows:

- a. Prepare solution containing 1:10 dilution of commercial sodium hypochlorite (%) as follows: one part household bleach (e.g., Clorox*) to nine parts of water.

CAUTION

Do not use any other cleaning and disinfecting agent, because it may corrode and damage head and cover. Do not reinstall rotor head or cover before rinsing and drying it thoroughly.

* Trademark of Clorox Company, Oakland, CA

- b. Remove rotor head from centrifuge, and soak head and cover in bleach solution for 10 minutes.

CAUTION

Remove head and cover from bleach solution promptly after 10 minutes of soaking. Prolonged exposure to bleach can corrode head and cover.

- c. Immerse parts completely in clean water. Rinse again under running water to remove all traces of bleach.
- d. Dry thoroughly both top and bottom surfaces of rotor head and cover. Oven drying may be used; however, oven temperature must not exceed 52°C (126°F).

CAUTION

Be sure that motor shaft, shaft pins, and attaching hardware are clean and dry before reassembling centrifuge.

If it is necessary to clean the rotor head without removing it from the centrifuge (not a recommended procedure), wipe it with a cloth moistened with water only. Do not use bleach solution. Avoid wetting the hub area; however, if wetted; accidentally, remove the rotor head and dry all parts. Do not wipe this area with any cleaning agent, because this area cannot be rinsed sufficiently while the rotor head is installed.

5.3.2 LUBRICATION

The centrifuge does not require lubrication. The centrifuge motor has permanently lubricated bearings.

5.3.3 VISUAL INSPECTION

Perform the inspection described in Table 5-2 every 4 months and at any time that the centrifuge is disassembled, such as after repair.

TABLE 5-2. VISUAL INSPECTIONS

<u>Item</u>	<u>Inspection</u>
Rotor Head	Top and bottom surfaces for cracks or deep scratches. (Replace rotor head if cracks are noted.) All surfaces for deep scratches. (Replace rotor head if deep scratches are noted.) All surfaces for dents (Replace rotor head if dents are noted.) Corrosion on surfaces, especially in region of motor shaft. (Replace rotor head if corrosion is noted in region of motor shaft.) Slots and all corners of top surface for dried-on residue. (Clean thoroughly if required.) While rotor head is off centrifuge, motor shaft, shaft adapter, and head nut for evidence of wear, corrosion, or damage. (Replace defective part, as applicable.)
Centrifuge Lid	Scratches and cracks.
Lid Seal Gasket	Cracks or other evidence of deterioration. (Replace gasket if required.)
Motor Brushes	Evidence of arcing or excessive wear (bottom cover removal required). (Replace brushes if required.)
Motor Ballmount	Ballmounts and bushings for cracks or other evidence of deterioration (bottom cover and motor removal required). (Replace ballmounts or bushings if required.)
Wiring	With bottom cover removed, motor wires and wires to timer circuit board for frayed, pinched, or broken wires (bottom cover removal required).

TABLE 5-2. VISUAL INSPECTIONS (Cont)

<u>Item</u>	<u>Inspection</u>
Timer Circuit Board	Resistors for charring or other evidence of overheating. Capacitors for leakage. Relay for arcing of contacts.
Cordset	Frayed, pinched, or broken wires. (Replace cordset if required.)
Step-Down Transformer (where applicable)	Frayed, pinched, or broken wires. (Replace transformer if required.)

5.3.4 PERIODIC CHECKS

5.3.4.1 Rotor Speed

Proceed as follows to check the rotor speed of the centrifuge with an Adams Photoelectric Tachometer:

- a. Unlatch and raise centrifuge lid, and check that centrifuge contains both rotor head and head cover and that they are tightened properly.
- b. Obtain target pick-up disc supplied with tachometer, remove its adhesive backing, and attach it as close as possible to center of knurled knob on head cover. Disc is small and round with black and silver half-circles.
- c. Lower and latch centrifuge lid.
- d. Press PUSH TO START/PUSH TO STOP switch to start centrifuge. Allow centrifuge to reach operating speed.
- e. Aim probe of tachometer through clear plastic lid, perpendicular to rotating target disc. Light beam of probe should be aimed to reflect from target disc.
- f. With range selector of tachometer set at 10,000, push PRESS TO READ switch of tachometer, and read lowest steady value. Speed must not exceed range of 10,500 RPM to 13,100 RPM.

NOTE

If speed of rotation is outside of limits, refer to Troubleshooting Table.

- g. Allow centrifuge to stop automatically, or press PUSH TO START/PUSH TO STOP switch to stop it manually.

5.3.4.2 Timer Accuracy

Check the internal timer periodically against a stopwatch as follows:

- a. Ensure that rotor head and head cover are installed, and close and latch centrifuge lid.
- b. Simultaneously press switch to start stopwatch and PUSH TO START/PUSH TO STOP switch to start centrifuge. Lens of switch on centrifuge will illuminate, indicating that motor is operating.
- c. Press switch to stop stopwatch when lens of PUSH TO START/PUSH TO STOP switch extinguishes. Lighted switch should go out within 5 minutes ± 30 seconds (4 minutes 30 seconds to 5 minutes 30 seconds).

If the timer exceeds the limits specified, refer to the Troubleshooting Table.

5.4 CORRECTIVE MAINTENANCE

5.4.1 VOLTAGES AND RESISTANCES

Transistor and integrated circuit socket on-terminal voltage and resistance values are not applicable to the centrifuge. The timer circuit board does not contain transistors, and the integrated circuits are soldered directly to the circuit board (are not socketed).

5.4.2 WAVEFORMS

Figure 5-1 identifies significant test points on the timer circuit board and waveforms to be expected at the test points.



5.4.3 TROUBLESHOOTING

Refer to the schematic diagram in Section 8 and to the troubleshooting information in Table 5-3.

TABLE 5-3. TROUBLESHOOTING TABLE

<u>Symptom</u>	<u>Probable Cause</u>	<u>Remedy</u>
Motor does not start. PUSH TO START/PUSH TO STOP switch not lighted.	Fuse blown on timer circuit board.	Replace fuse.
Motor does not start, but PUSH TO START/PUSH TO STOP switch lighted.	Motor brushes worn excessively.	Replace brushes.
	Relay K1 contacts stuck or solenoid defective.	Replace relay.
	Lid switch defective.	Replace switch.
	Timer circuit board defective.	Replace circuit board.
Motor starts, but rotor speed below 10,500 RPM.	Governor brushes in motor worn excessively.	Replace brush plate assembly.
	Governor not set correctly or failed.	Replace governor.
Motor starts, but rotor speed above 13,100 RPM	Governor not set correctly.	Replace governor.
	Motor resistor or capacitor defec- tive.	Replace resistor or capacitor.

5.4.4 DISASSEMBLY/REASSEMBLY

5.4.4.1 Line Fuse

NOTE

Do not replace line fuse without first verifying that it has blown. If PUSH TO START/PUSH TO STOP switch illuminates when centrifuge is turned on, fuse is good.

The line fuse is located internally to the centrifuge. Proceed as follows to replace the fuse:

- Disconnect power cord from wall/bench receptacle.
- Close lid, and invert centrifuge onto clean pad or soft cloth.
- Detach cover (Figure 5-2) by removing three attaching screws and lockwashers that secure cover to base of housing. Do not remove rubber feet from bottom cover.
- Remove line fuse from spring clips on timer circuit board, and snap in correct replacement. (Correct fuse is 4-ampere Slo-Blo, 3AG. Littlefuse Type 313, or approved equivalent.)

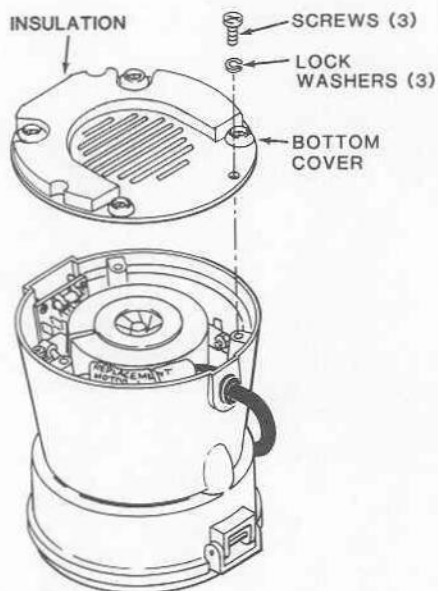


Figure 5-2. Removal of Bottom Cover

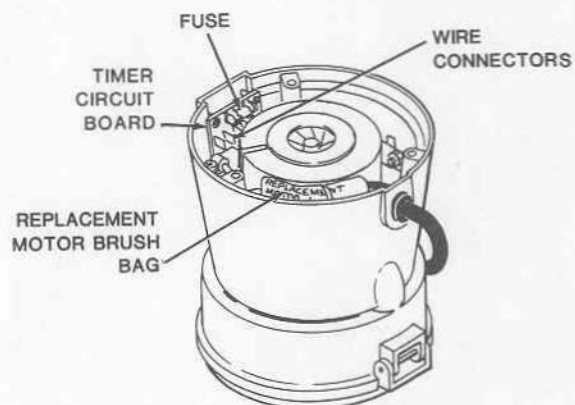


Figure 5-3. Fuse Replacement

- e. Reassemble bottom cover to base of housing, using screws and lockwashers removed in Step c.
- f. Turn centrifuge right-side up.
- g. Reconnect power cord to wall/bench receptacle, and check for correct operation of PUSH TO START/PUSH TO STOP switch and motor.

5.4.4.2 Motor

Proceed as follows to remove the centrifuge motor to gain access to other parts or to replace the complete motor:

- a. Disconnect power cord from wall/bench receptacle.
- b. Place pins on head nut wrench into holes of head nut; holding rotor head with one hand, turn wrench counterclockwise to loosen head nut.
- c. Remove head nut from motor shaft.
- d. Remove rotor head from motor shaft.
- e. Remove motor shaft adapter from motor shaft (Figure 2-2).
- f. Close lid, and invert centrifuge onto clean pad or soft cloth.
- g. Detach bottom cover (Figure 5-2) by removing three attaching screws and lockwashers that secure cover to base of housing. Do not remove rubber feet from bottom cover.
- h. Refer to Figure 5-4, and loosen three Phillips-head screws that attach motor and support bracket to housing.
- i. Raise motor (with support bracket and ballmount hardware) until it is clear of housing.

NOTE

If replacing part other than motor, stop disassembly at this point and proceed to appropriate disassembly/replacement procedure.

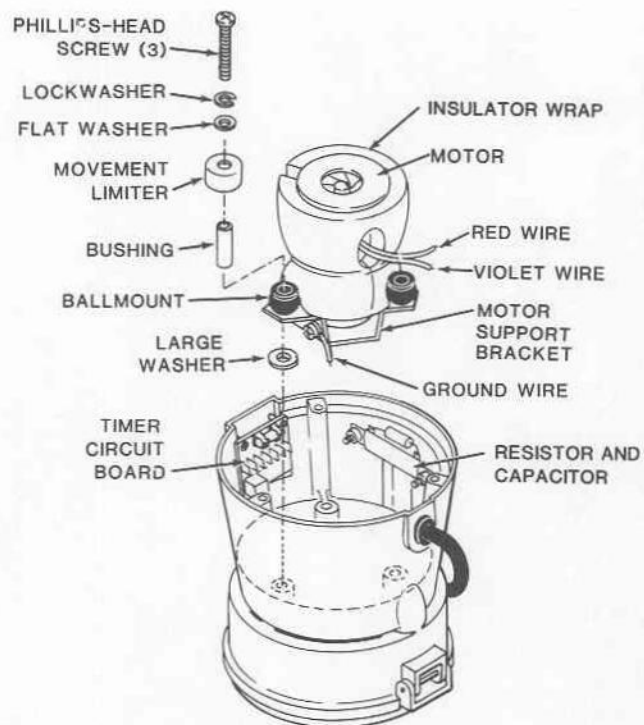


Figure 5-4. Motor Ballmount Attaching Hardware

- j. Remove attaching hardware from three ballmounts and bushings (Phillips-head screws, lockwashers, flat washers, and movement limiters). Save hardware for reuse.
- k. Refer to Figure 5-5. Hold motor in raised position, and disconnect ground wire (green with yellow stripe) from bottom of motor support bracket.
- l. Remove attaching screw and lockwasher from cable clamp at left of timer circuit board.
- m. Cut cable tie that secures yellow, pink, blue, black, and white wires.
- n. Disconnect following motor wires from their pin connectors on timer circuit board (see Figure 5-5):
 - Yellow wire (4)
 - Pink wire (2)
 - Blue wire (1) (crimped in terminal with white line cord wire)
- o. Disconnect violet wire (3) from pin connector on timer circuit board.

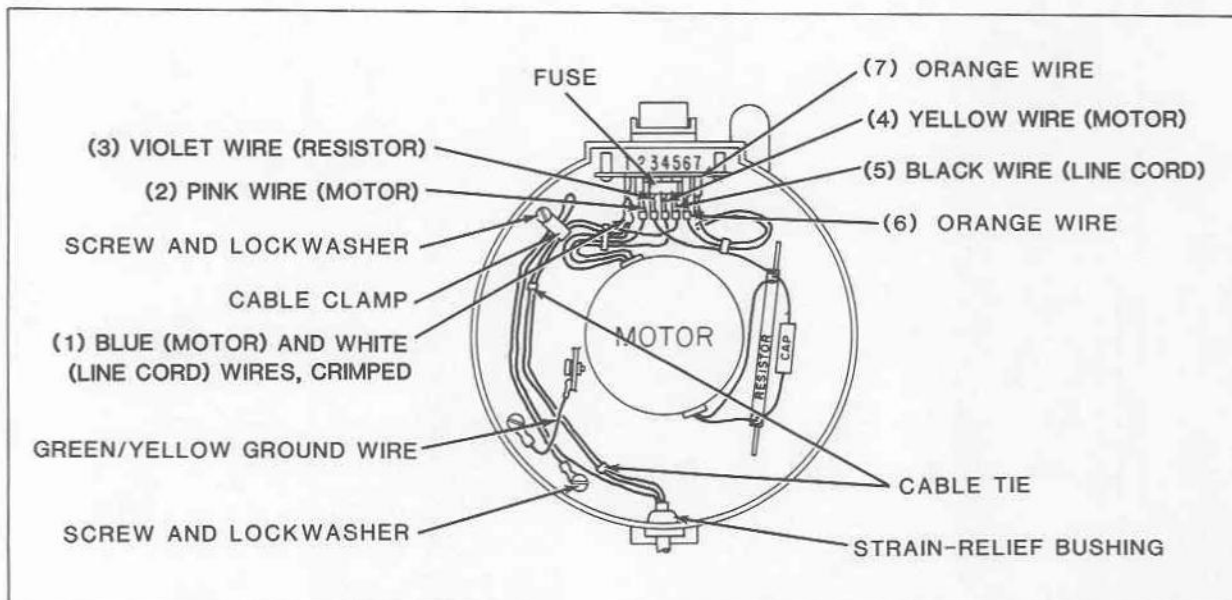


Figure 5-5. Timer Circuit Board, External Wire Connections

- p. Cut cable tie that secures violet wire to two orange wires from lid switch.
- q. Disconnect crimped violet wires and red wire from their pin connectors on motor resistor. (Motor capacitor is soldered between violet wire and red wire terminals.)
- r. Cut quick-connect terminal from blue and white wires.
- s. Carefully place motor on bench or counter.
- t. Slip sound insulation sleeve with cable tie from motor.
- u. Disconnect old motor from motor support bracket by removing four screws and lockwashers from shaft end of motor.
- v. Connect new motor to motor support bracket, using screws and lockwashers removed in Step u. Orient motor such that its ground wire (see Step k.) is on side toward motor support bracket. Reconnect ground wire to motor support bracket.
- w. Using new quick-connect terminal, crimp together blue and white wires.
- x. Bunch together yellow, pink, blue, black, and white wires, and use new cable tie to secure them. Reconnect motor wires to timer circuit board.

- y. Insert wires into cable clamp, and use screw and lockwasher from Step 1 to attach cable clamp at left of timer circuit board.
- z. Refer to Figure 5-9, and ensure that large washers are in position over motor mounting pads. Orient motor and support bracket correctly, and gently lower assembly onto washers. Check to see that washers remained in position over mounting pads.

CAUTION

Be sure that ballmount bushings are in place and do not slip out during reassembly. Ballmounts are unidirectional; if they are removed or they slip out, they must be reassembled correctly.

- aa. Reassemble attaching hardware of each ballmount exactly as shown in Figure 5-9; then tighten ballmount screws securely.
- ab. Bunch together violet and two orange wires, and use new cable tie to secure them.
- ac. Reconnect two violet wires and red motor wire to terminals on motor resistor. (Motor capacitor is soldered between connectors of violet and red wires.)
- ad. Slide sound insulating sleeve (removed in Step t.) around motor, and push down until seated.
- ae. Replace bottom cover by installing three attaching screws and lockwashers removed in Step g.
- af. Turn centrifuge right-side up, and lower motor shaft adapter, flange upward, such that hole in adapter slips over shaft.
- ag. Place D-shaped hole of rotor head onto threaded D-shaped rotor shaft. Ensure that rotor is fully bottomed on motor shaft and motor shaft adapter.
- ah. Thread hex nut onto motor shaft, flange side up.
- ai. Place pins on head nut wrench into holes of head nut; holding rotor head with one hand, turn wrench clockwise to tighten head nut.
- aj. Reconnect power cord to wall/bench receptacle.

CAUTION

Never operate centrifuge unless rotor head is installed. Operation without rotor head may damage motor governor.

5.4.4.3 Motor Brushes

NOTE

One set of replacement motor brushes is contained in bag taped to power cord wires, next to motor.

- a. Remove motor from centrifuge by performing Steps a. through i. of procedure in Paragraph 5.4.4.2.
- b. Slip sound insulation sleeve with attached cable tie from motor (Figure 5-6).
- c. Use blade of flat screwdriver to pry off two snap-out caps (Figure 5-6)..
- d. Refer to Figure 5-7, and unscrew slotted brush caps from inside motor enclosure. Brush contact plate should spring out when brush cap is removed; if not, use small screwdriver carefully to pry out brush assembly.
- e. Orient curved surface of each brush so that it matches curvature of motor housing as shown in Figure 5-8.
- f. Insert first brush into motor enclosure, press in spring and brush contact plate, and replace threaded brush cap.
- g. Repeat Step f. for second brush.
- h. Replace two snap-out caps on motor enclosure.
- i. Refer to Figure 5-9, and ensure that large washers are in position over motor mounting pads. Orient motor and support bracket correctly, and gently lower assembly onto washers.

CAUTION

Be sure that ballmount bushings are in place and do not slip out during reassembly.

- j. Reassemble attaching hardware of each ballmount exactly as shown in Figure 5-9; then tighten ballmount screws securely.
- k. Reassemble centrifuge by performing Steps ad. through aj. of procedure in Paragraph 5.4.4.2.

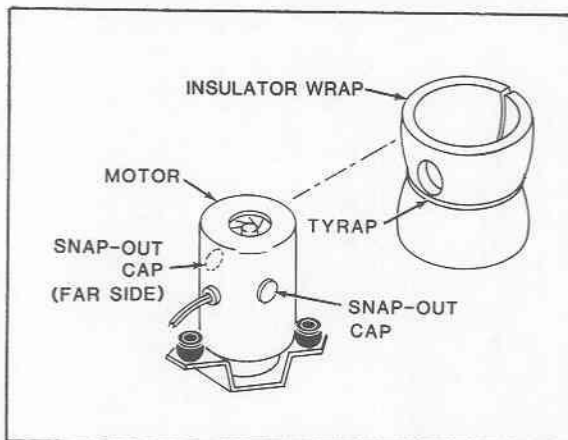


Figure 5-6. Motor Enclosure Snap-Out Caps

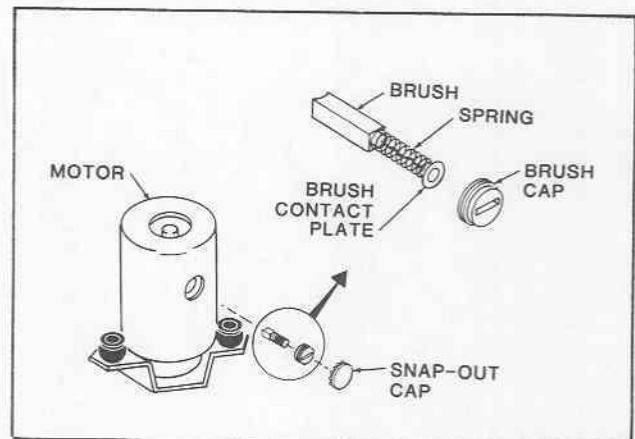


Figure 5-7. Brush Assembly Removal

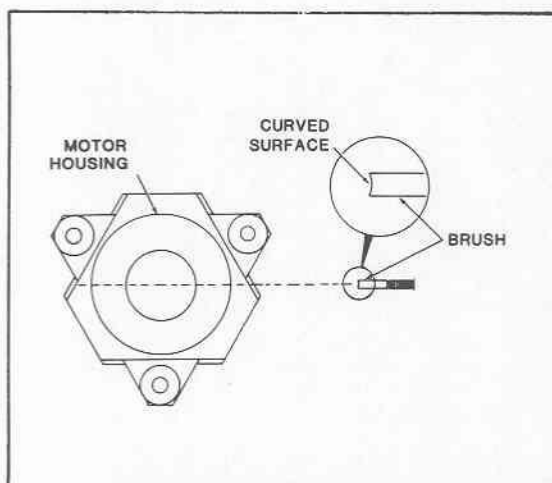


Figure 5-8. Motor Brush Orientation

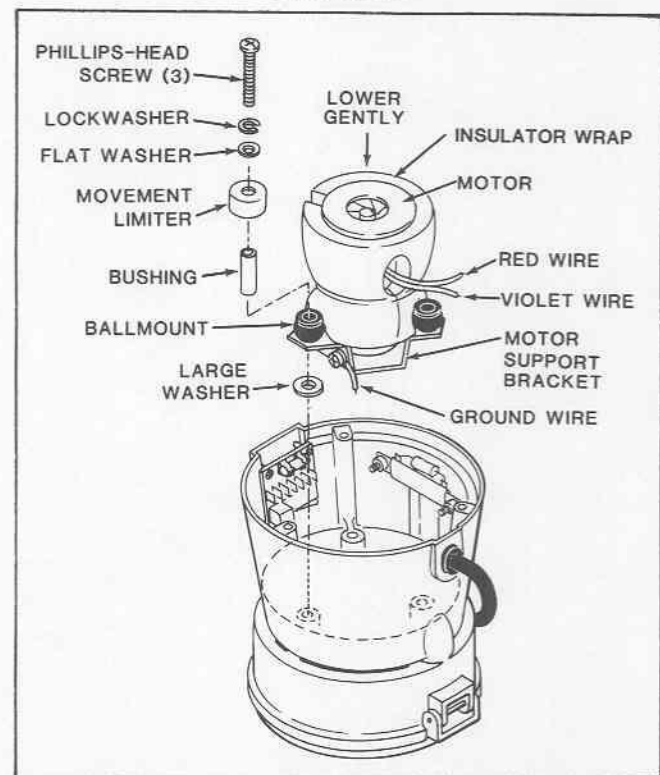


Figure 5-9. Motor and Ballmount Installation

5.4.4.4 Governor Brushes

Proceed as follows to replace worn governor brush plate assembly:

- a. Remove motor from centrifuge by performing Steps a. through t. of procedure in Paragraph 5.4.4.2.
- b. Remove two slotted screws and lockwashers from each side of motor (Figure 5-10).
- c. Pull up motor housing, slipping motor wires through rubber grommets on sides of housing, until fan and governor are accessible.

NOTE

Mark locations of fan and governor to maintain circumferential locations for balance.

- d. Loosen single set screw on hub of fan (Figure 5-10), using 5/64" Allen wrench, and remove fan from motor shaft.
- e. Loosen two set screws on hub of governor assembly (Figure 5-11), and remove assembly.
- f. On brush plate assembly, pry off spring contacts of violet and red wires from brass brush holders.
- g. Remove four screws and lockwashers from governor brush plate assembly, and remove assembly.
- h. On replacement brush plate assembly, insert spring contacts of violet and red wires through plastic grommet.
- i. Turn brush plate assembly so that outer and inner brushes are oriented as shown in Figure 5-12.
- j. Attach brush plate assembly to motor using four screws and lockwashers removed in Step g.
- k. Snap spring contacts of wire leads onto brass brush holders as follows:
 - Violet wire onto inner brush holder.
 - Red wire onto outer brush holder.
- l. Slide governor assembly partially onto motor shaft.

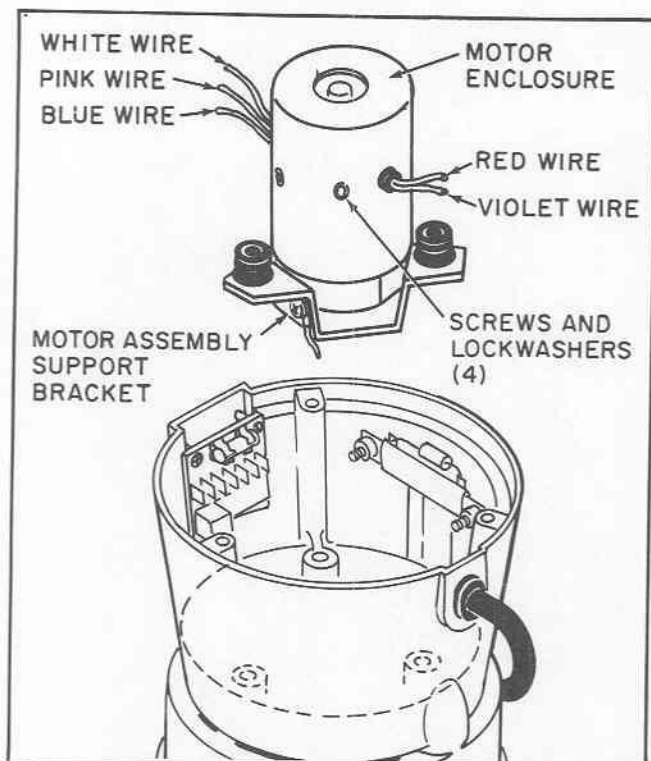


Figure 5-10. Removal of Motor Enclosure

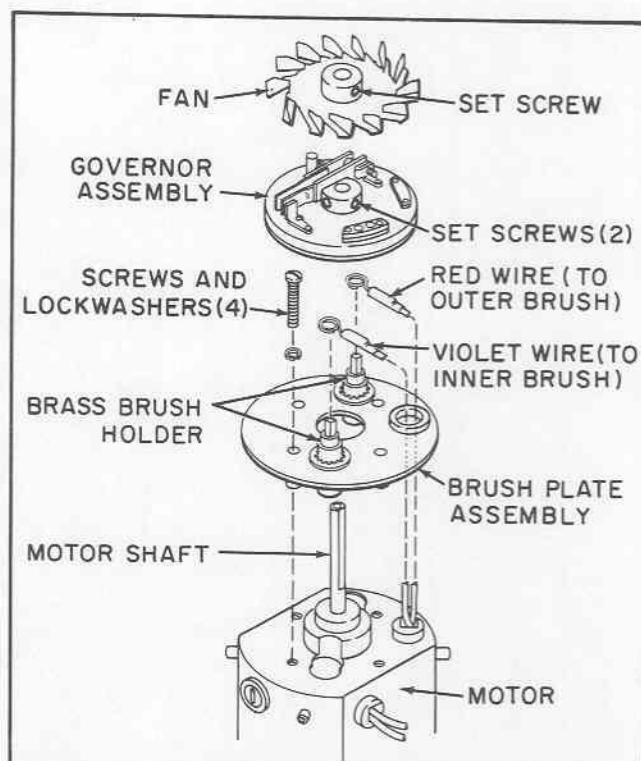


Figure 5-11. Fan and Governor Assembly Details

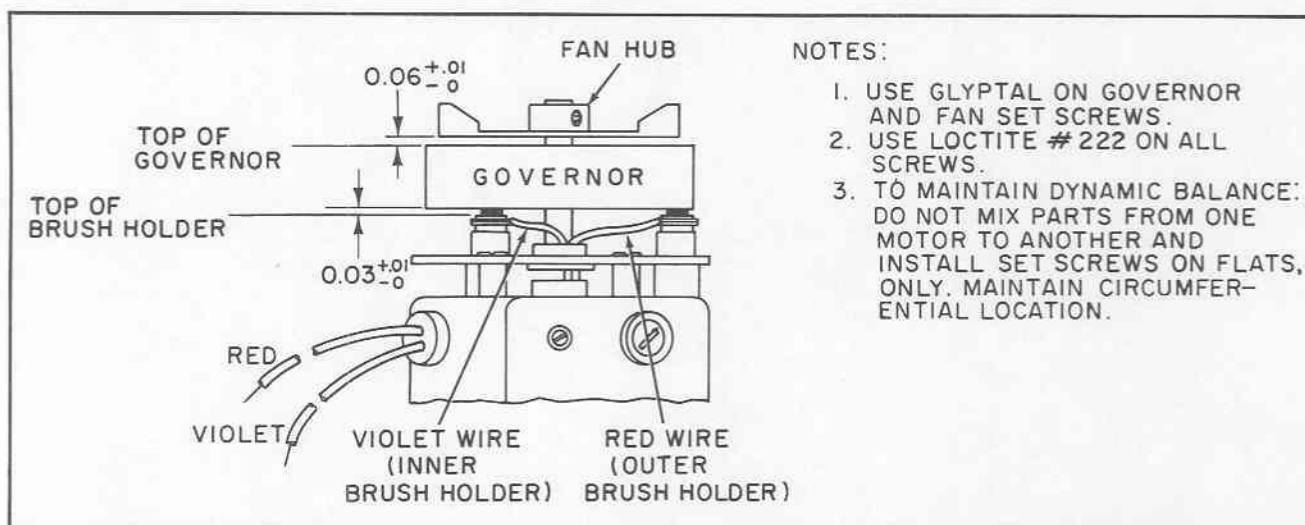


Figure 5-12. Governor Brush Assembly Details

- m. Use 0.03-inch (+0.01, -0.0 inch) shim to adjust clearance between bottom of governor assembly and top of brass brush holders. Tighten two set screws, and use LOCTITE #222 on both set screws.
- n. Reinstall fan on motor shaft. Use 0.06 (+0.01, -0.0) inch shim to adjust clearance between fan and governor. Tighten set screw, and use LOCTITE #222 on set screw. Re-form fan blades if bent.
- o. Reassemble centrifuge by performing Steps a. through c. of this procedure and Steps a. through q. of Paragraph 5.4.4.2 in reverse order.

5.4.4.5 Lid-Seal Gasket

Proceed as follows to replace the lid-seal gasket:

- a. Remove old gasket by peeling it from groove in housing.
- b. Scrape or rub off any residual adhesive remaining in gasket groove.
- c. Apply thin bead of PERMABOND White Label Gasket Seal (or equivalent adhesive for bonding rubber material) around bottom of gasket groove.

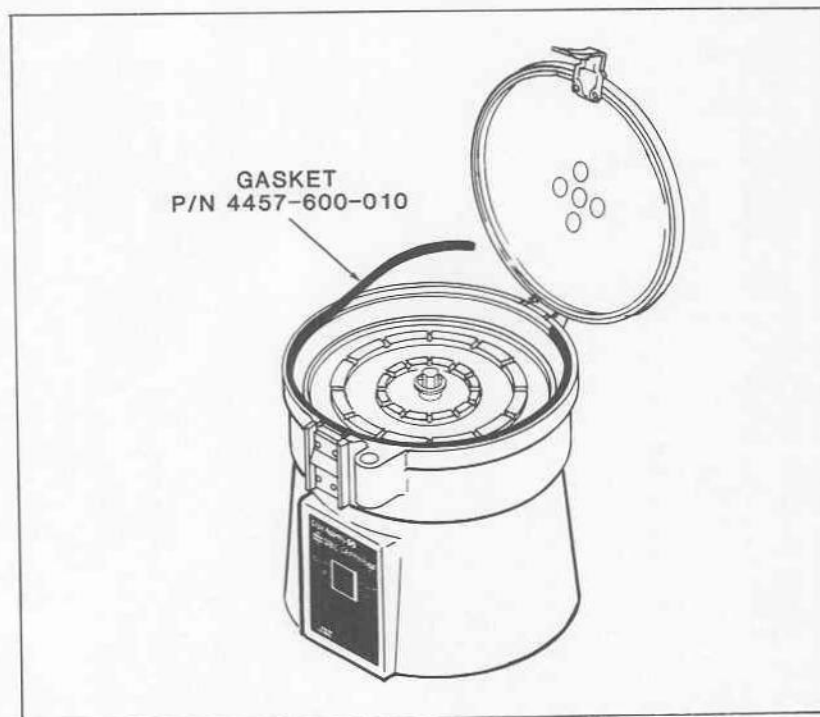


Figure 5-13. Lid-Seal Gasket Installation

- d. Orient new gasket as shown in Figure 5-13, and press firmly around circumference of groove. Make sure that open space between ends of gasket is at rear of centrifuge.
- e. Allow adhesive to dry before closing lid.

5.4.4.6 Timer Circuit Board

Proceed as follows to replace the timer circuit board:

CAUTION

The timer circuit board contains MOS devices, which are subject to damage from electrostatic discharge (ESD). Refer to Paragraph 1.8 for information pertaining to proper handling.

- a. Detach bottom cover (Figure 5-2) by removing three attaching screws and lockwashers that secure cover to base of housing. Do not remove rubber feet from bottom cover.
- b. Remove quick-connect terminals from pin connectors on timer circuit board.
- c. Peel off front panel to access screws that attach timer circuit board to frame of centrifuge.
- d. Remove four attaching screws from front of centrifuge, and move board toward center of centrifuge so that POWER switch slides evenly out of front panel. Press in POWER switch to gain clearance.
- e. Install new timer circuit board by performing Steps a. (Figure 5-5) through c. in reverse order. Circuit board replacement includes new front panel with adhesive back.
- f. Replace bottom cover by installing three attaching screws and lockwashers removed in Step a.

5.4.4.7 Cordset

Proceed as follows to replace the cordset:

- a. Detach bottom cover (Figure 5-2) by removing three attaching screws and lockwashers that secure cover to base of housing. Do not remove rubber feet from bottom cover.
- b. Remove attaching screw and lockwasher from cable clamp at left of timer circuit board.
- c. Remove screw and external-tooth lockwasher from ground near cordset entrance.
- d. Cut cable tie that secures yellow, pink, blue, black, and white wires.
- e. Cut two cable ties that secure black and white wires. If bag holding spare motor brushes still is wrapped around cordset wires, cut cable tie and remove and set aside bag.
- f. Disconnect white wire (crimped with blue line cord wire) from its pin connector on timer circuit board.
- g. Cut quick-connect terminal from blue and white wires.
- h. Compress rear of strain-relief bushing (grommet), and pop out bushing from outside of centrifuge.
- i. Install new cordset by performing Steps a. through h. in reverse order. Use new cable ties where old ones were cut.
- f. Replace bottom cover by installing three attaching screws and lockwashers removed in Step a.

SECTION 6. STORAGE

6.1 INDOOR STORAGE

Prepare the centrifuge for indoor storage as follows:

- a. Remove rotor cover, head nut, and rotor head.
- b. Package rotor components in their original packing materials.
- c. Place centrifuge in plastic bag, seal bag with tape, and return all parts to their original shipping carton as shown in Figure 2-1.

Specialized heating or cooling equipment is not required, provided the environmental conditions in the storage area do not exceed the following limits:

Temperature: -26° to 55°C (-15° to 131°F)

Relative Humidity: 10% to 95%, non-condensing

The external packaging container should be inspected visually on a routine basis. Internal inspection of the centrifuge is not required.

If the centrifuge has been in storage for 2 years or more and will be placed into operation, it should be referred to a qualified serviced technician for inspection and performance evaluation before centrifuging blood for medical diagnostic purposes. Particular attention should be paid to visual inspection of the foam lid-seal gasket for signs of deterioration and the rubber ballmounts for the motor for signs of cracks. Estimated storage life of these components, under the specified environmental conditions, is approximately 5 years.

. The technician should inspect the centrifuge and evaluate its performance before using it to centrifuge blood for medical diagnostic purposes.

6.2 OUTDOOR STORAGE

The QBC Centrifuge is not recommended for outdoor storage unless the environmental conditions specified in Paragraph 6.1 can be maintained and the complete system has been packaged in a waterproof container. Refer the centrifuge to a qualified service technician if the container shows evidence of exposure to water or moisture.

SECTION 7. PARTS LIST

This section identifies replacement parts on the QBC Centrifuge.

The left column of parts lists that are primarily mechanical refers to the illustration on which the part is shown (i.e., 1- refers to Figure 1. The exact location of the part on the illustration is identified by an index number on the referenced illustration (e.g., -6). The full identification of the part location for the example given, therefore, would be "1-6."

The left column of parts lists that are primarily electrical refers to the illustration on which the part is shown (i.e., 2- refers to Figure 2. The exact location of the part on the illustration is identified by the reference designation of the part, which is silk-screened on the circuit board (e.g., -R1). The full identification of the part location for the example given, therefore, would be "2-R1."

The "Part/Reorder No." column identifies the number that should be used to order a replacement part from Becton Dickinson.

The "Description" column provides a brief listing of what the part is and how it may be distinguished from another part with a similar name. The numbers at the top of the column (1 2 3 4 5) are used to designate generation levels for mechanical items, "1" being the highest level. The description of each item is indented to show the degree of subordination to the assembly being broken down. Dots are used to fill the spaces for the higher level(s). Item 1-14 (BRUSH AND CAP SET), for example, is identified by two dots to show that it is part of Item 1-13 (MOTOR , with capacitor), the next prior one dot).

The "Quantity per Assembly" column identifies the total quantity used for of that part. Where a part is shown on more than one illustration, the quantity is given only for the first listing of the part; subsequent listings contain "REF" (reference) as the quantity.

Figure & Index No.	Part/Reorder No.	Description	Quantity per Assembly
		1 2 3 4 5	
1-	Model 4207	CENTRIFUGE	REF
-1	4457-600-011	. LID	1
-2	0591-603-001	. LATCH, lid	1
-3	4457-601-000	. COVER ASSY, head	1
-4	4457-600-034	. NUT, head	1
-5	4207-601-000	. HEAD ASSY, rotor	1
-6	4457-600-010	. SEAL, lid	1
-7	4457-600-002	. CATCH PLATE	1
-8	4457-605-000	. SWITCH ASSY, lid	1
-9	4457-600-035	. CUSHION, switch	1
-10	4457-600-013	. GASKET, foam	1
-11	4457-600-019	. ADAPTER, motor shaft	1
-12	4457-600-031	. INSULATION, sound, motor	1
-13	4457-603-001	. MOTOR, with capacitor	1
-14	4457-616-002	. . BRUSH AND CAP SET	1
-15	4457-603-004	. . GOVERNOR BRUSHES ASSY, motor	1
-16	4457-618-510	. . CAPACITOR, 0.22 UF, 200 WVDC	1
-17	4457-616-015	. . RESISTOR, 20 ohms $\pm 5\%$, 55 W	1
-18	0558-600-004	. BALLMOUNT KIT, motor, in- cludes:	1
		. . BALLMOUNT	3
		. . BUSHING	3
		. . WASHER, ballmount	3
		. . WASHER, flat, #10	3
		. . LOCKWASHER, split, #10	3
		. . SCREW, pan hd, Phillips, #10-32 x 1-1/2 in.	3
		. . LIMITER, movement	3
-19	4457-600-006	. CIRCUIT BOARD, timer (see Fig. 2)	1
	4207-100-002	. . NAMEPLATE, front panel, provided w/ckt board	1
-20	4200-600-004	. FOOT	4
-21	4457-607-000	. CORDSET ASSY	1
-22	2510-623-819	. FUSE, 4 amp, Slo-Blo, (Littlefuse 3AG-4A-313) (see Fig. 2)	1
-23	4207-513-128	. FUSE CLIP: timer board	2
-24	4207-513-127	. STANDOFF: timer board	4
-25	4457-614-000	WRENCH, head nut	1

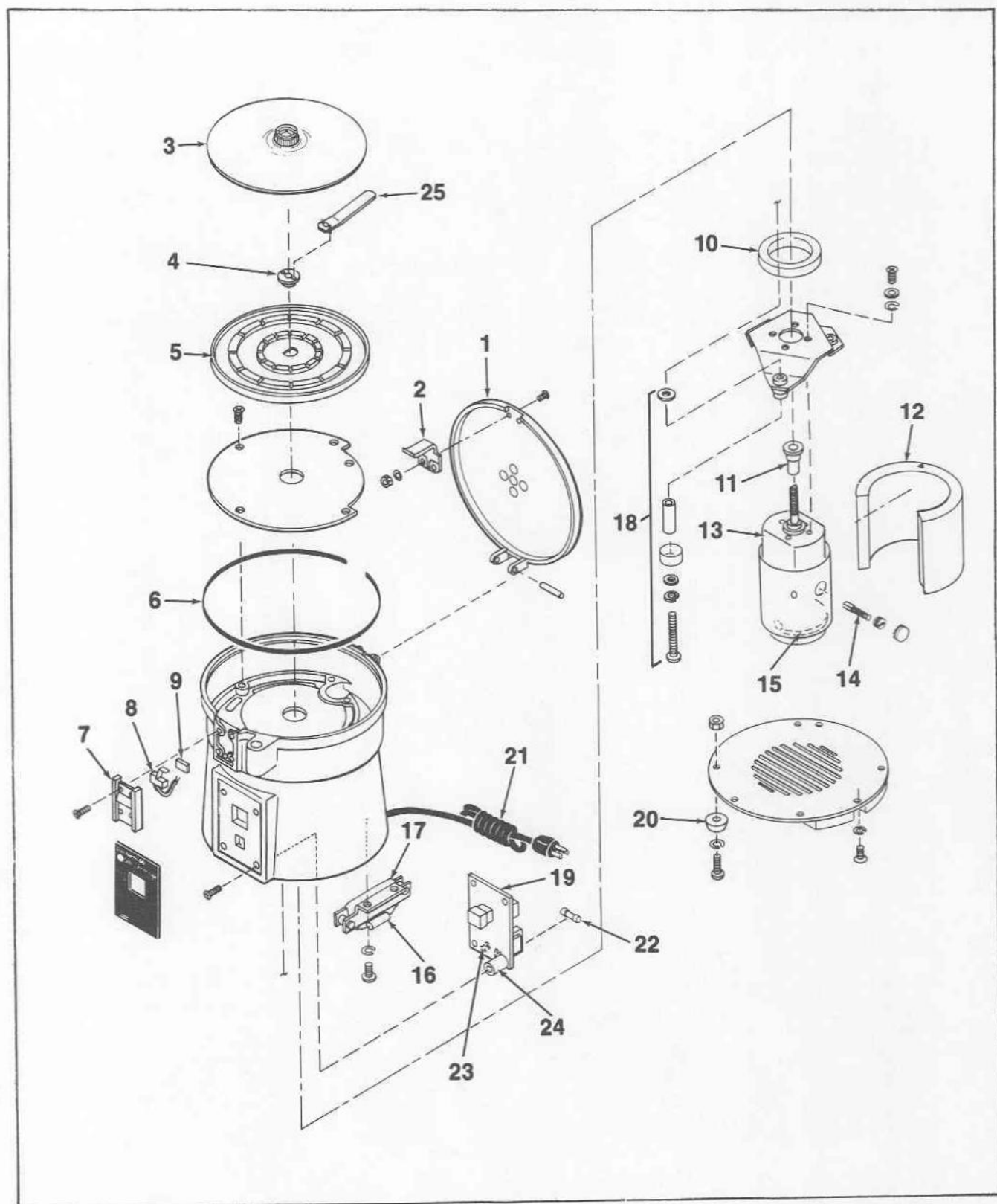


Figure 1. Centrifuge Model 4207, Exploded View Drawing

Figure & Ref. Desig.	Part/Reorder No.	Description	Quantity per Assembly
2-	4457-600-006 (4457-100-006)	CIRCUIT BOARD, timer	REF
-C1	4207-513-209	CAPACITOR, alum elect: 47 UF, 16WVDC, radial leads	1
-C2	4207-513-210	CAPACITOR, alum elect: 4.7 UF, 16WVDC, radial leads	1
-C3	4207-513-211	CAPACITOR, disc: 0.1 UF, 25 WVDC	2
-C4	4207-513-211	CAPACITOR, disc: same as C3	REF
-C5	4207-513-212	CAPACITOR, ceramic: 0.012 UF, +5% 25 WVDC	1
-C6	4207-513-213	CAPACITOR, disc: 5000 pF, 500 WVDC	1
-C7	4207-513-214	CAPACITOR, arc suppressor, Centralab 0.02 UF, 1,000 WVDC, 2-3 kV arc	2
-C8	4207-513-214	CAPACITOR, same as C7	REF
-CR1	4207-513-215	DIODE, silicon rectifier, 1 A, 1,000 PIV, 1N4007	9
-CR2	4207-513-215	DIODE: same as CR1	REF
-CR3	4207-513-215	DIODE: same as CR1	REF
-CR4	4207-513-215	DIODE: same as CR1	REF
-CR5	4207-513-215	DIODE: same as CR1	REF
-CR6	4207-513-215	DIODE: same as CR1	REF
-CR7	4207-513-215	DIODE: same as CR1	REF
-CR8	4207-513-215	DIODE: same as CR1	REF
-CR9	4207-513-215	DIODE: same as CR1	REF
-CR10	4207-513-216	DIODE, Zener: 12 V, 1 W	1
-DS1	4207-511-004	LAMP (p/o S1) #7839	1
-F1	2510-623-819	FUSE, 4 amp, Slo-Blo, (Littlefuse 3AG-4A-313) (see Fig. 1)	REF
-K1	4207-513-203	RELAY (Aromat HC2-P-AC115V)	1
-M1	4207-513-208	ARC SUPPRESSOR, MOV type, (Maida Dev. Co. D73ZOV301RA25)	2
-M2	4207-513-206	ARC SUPPRESSOR, MOV type, (GE V150LA2)	1
-M3	4207-513-208	ARC SUPPRESSOR: same as M1	REF
-Q1	4207-513-204	SILICON CONTROLLED RECTIFIER, Artisan Controls 1136	1
-R1	4207-513-218	RESISTOR: 2 ohms, 10, W (Dale CP-10-2)	1
-R2	4207-513-219	RESISTOR: 20 kilohms, 1/2 W,	2
-R3	4207-513-219	RESISTOR: same as R2	REF
-R4	4207-513-220	RESISTOR: 10 kilohms, 1/4 W	3
-R5	4207-513-221	RESISTOR: 5100 ohms, 1 W	2

<u>Ref. Desig.</u>	<u>Part/Reorder No.</u>	<u>Description</u>	<u>per Assembly</u>
-R6	4207-513-221	RESISTOR: same as R5	REF
-R7	4207-513-222	RESISTOR: 100 kilohms, 1/4 W	1
-R8	4207-513-220	RESISTOR: same as R4	REF
-R9	4207-513-223	RESISTOR: 1 megohm, 1/4 W	2
-R10	4207-513-224	RESISTOR: 10 ohms, 1/4 W	3
-R11	4207-513-220	RESISTOR: same as R4	REF
-R12	4207-513-207	RESISTOR: same as R9	REF
-R13	4207-513-225	RESISTOR: 330 kilohms, 1/4W	1
-R14	4207-513-226	RESISTOR: 6800 ohms, 1/4 W	1
-R15	4207-513-217	RESISTOR: 1000 ohms, 1/4 W	1
-R16	4207-513-224	RESISTOR: same as R10	REF
-R17	4207-513-224	RESISTOR: same as R10	REF
-S1	2510-625-334	SWITCH (EAO 99-450)	1
	2510-625-336	CAP ASSY, Lens (p/o S1) (EAO 99-901.9)	1
-U1	4207-513-201	INTEGRATED CIRCUIT, MOS, dual J-K flip-flop (RCA CD4027BE)	1
-U2	4207-513-202	INTEGRATED CIRCUIT, MOS (Artisan Controls 1334)	1

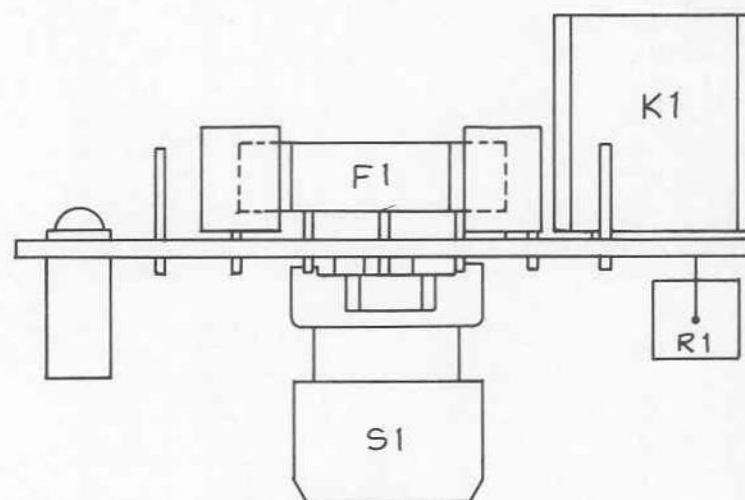
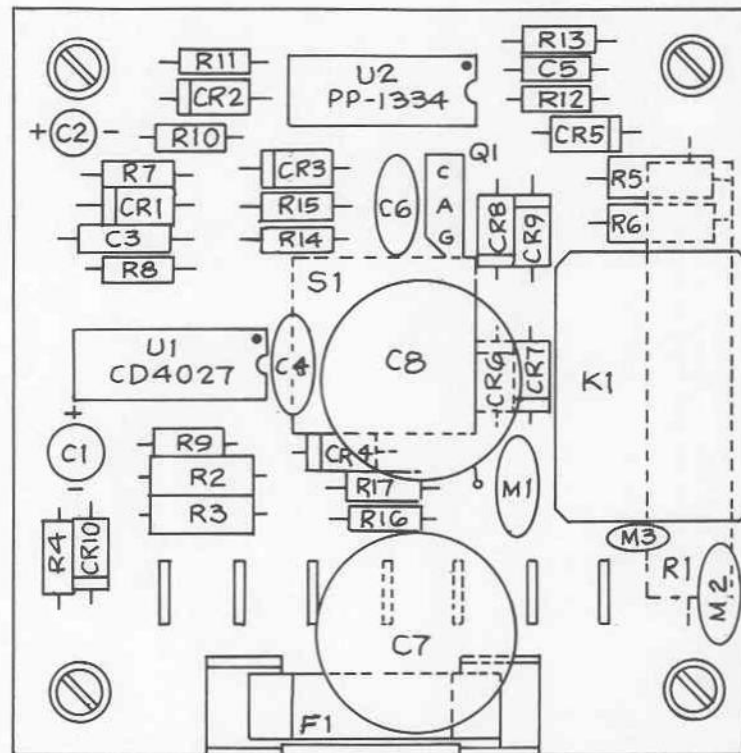


Figure 2. Timer Circuit Board

SECTION 8. DRAWINGS

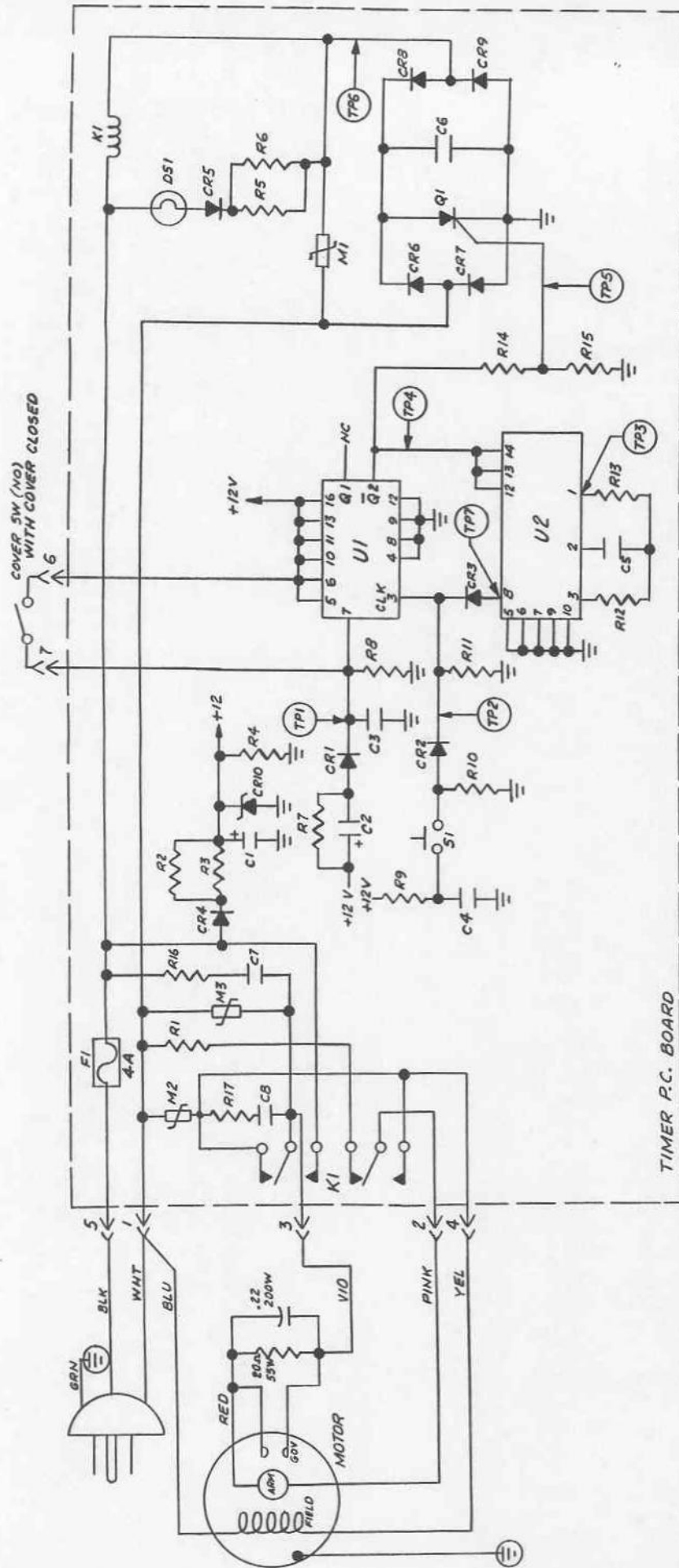


Figure 8-1. Centrifuge.
Schematic Diagram

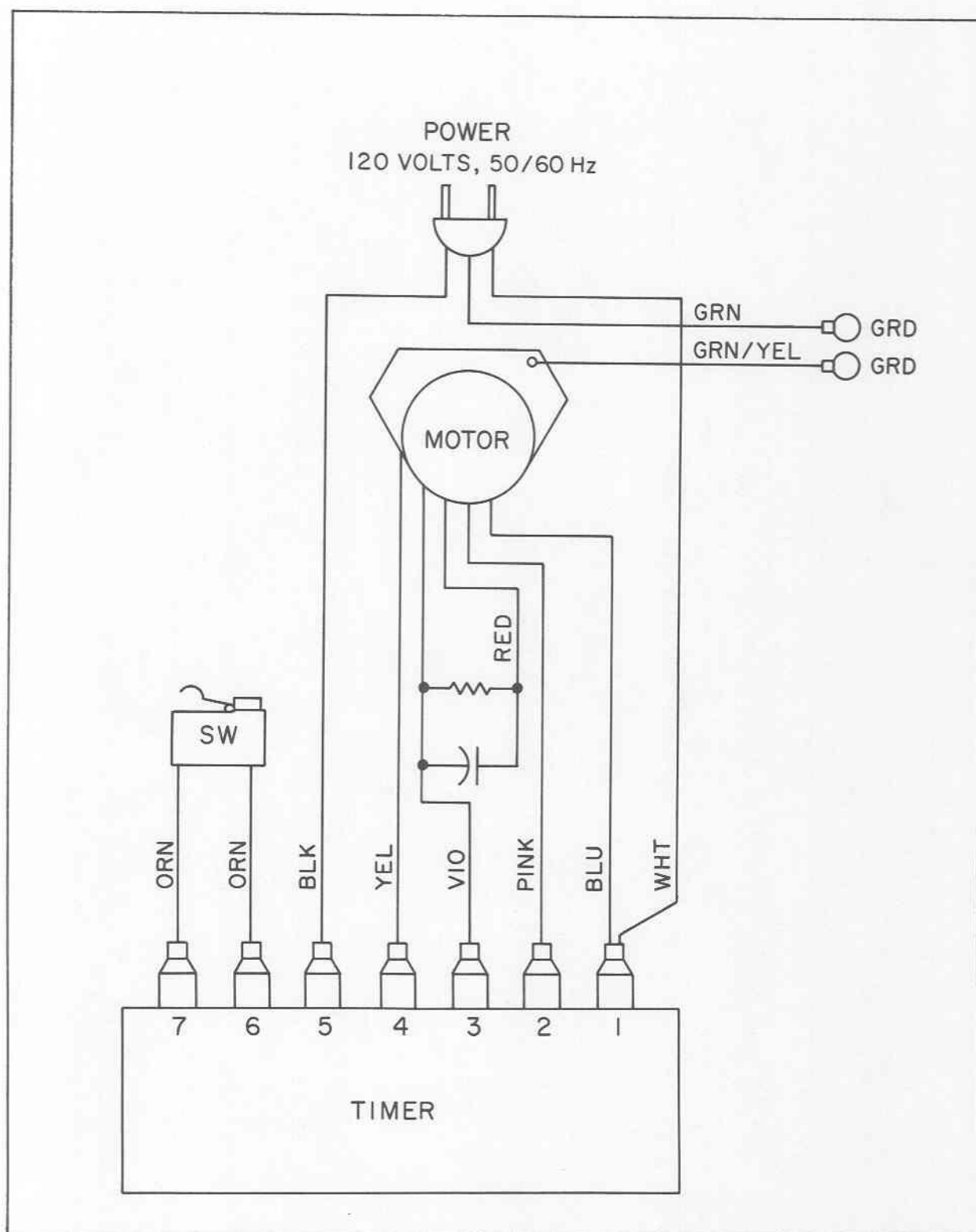


Figure 8-2. Centrifuge, Internal Wiring

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